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The Colorado River Aqueduct

An Outline of the Plan for Making a Portion of the Water of the Colorado River, Conserved by the Hoover Dam, Available to Los Angeles and Her Sister Cities of the Southwest

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THE Hoover dam, creating a storage space of 30,500,000 acre feet, is proposed as a means of regulating the flow of the Colorado River, both to make it available for beneficial use and to afford protection against floods. Incidentally, it will release a large block of power, badly needed to support the industrial development of the Southwest. With this reservoir in operation, the dependable flow of the river will be greatly augmented, making it possible to supply water to a largely increased population. Los Angeles and her sister cities hope to secure a portion of this increased flow for a domestic supply and to accomplish this purpose have formed a confederation, known as "The Metropolitan Water District of Southern California."

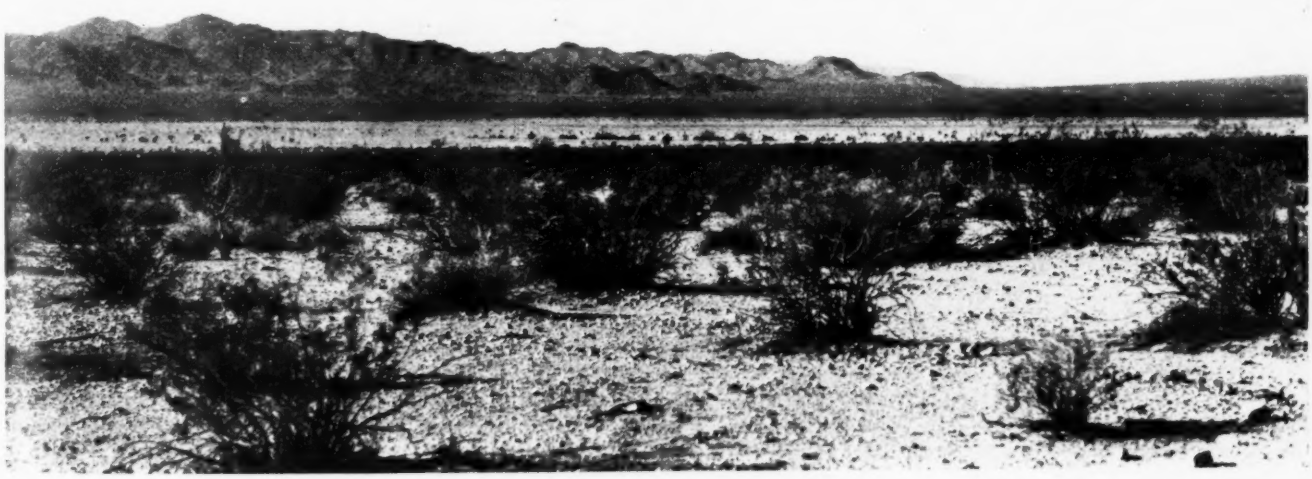
The Metropolitan Water District.—The District at present (May, 1931) is composed of 14 cities with a combined population of 1,699,000 and an assessed valuation of $2,420,000,000. Other cities are expected to join. The district was organized for the specific purpose of importing water from the Colorado River and at present has no other purpose. The plans contemplate the diversion of a continuous flow of 1,500 second feet which, after deducting for losses in transit, will almost double the present water supply.

The cities of the district are not within the Colorado River watershed but are situated in what is generally referred to as the South Coastal Basin. The Colorado River water must be brought into the district across a major divide, through an aqueduct some 250 miles long.

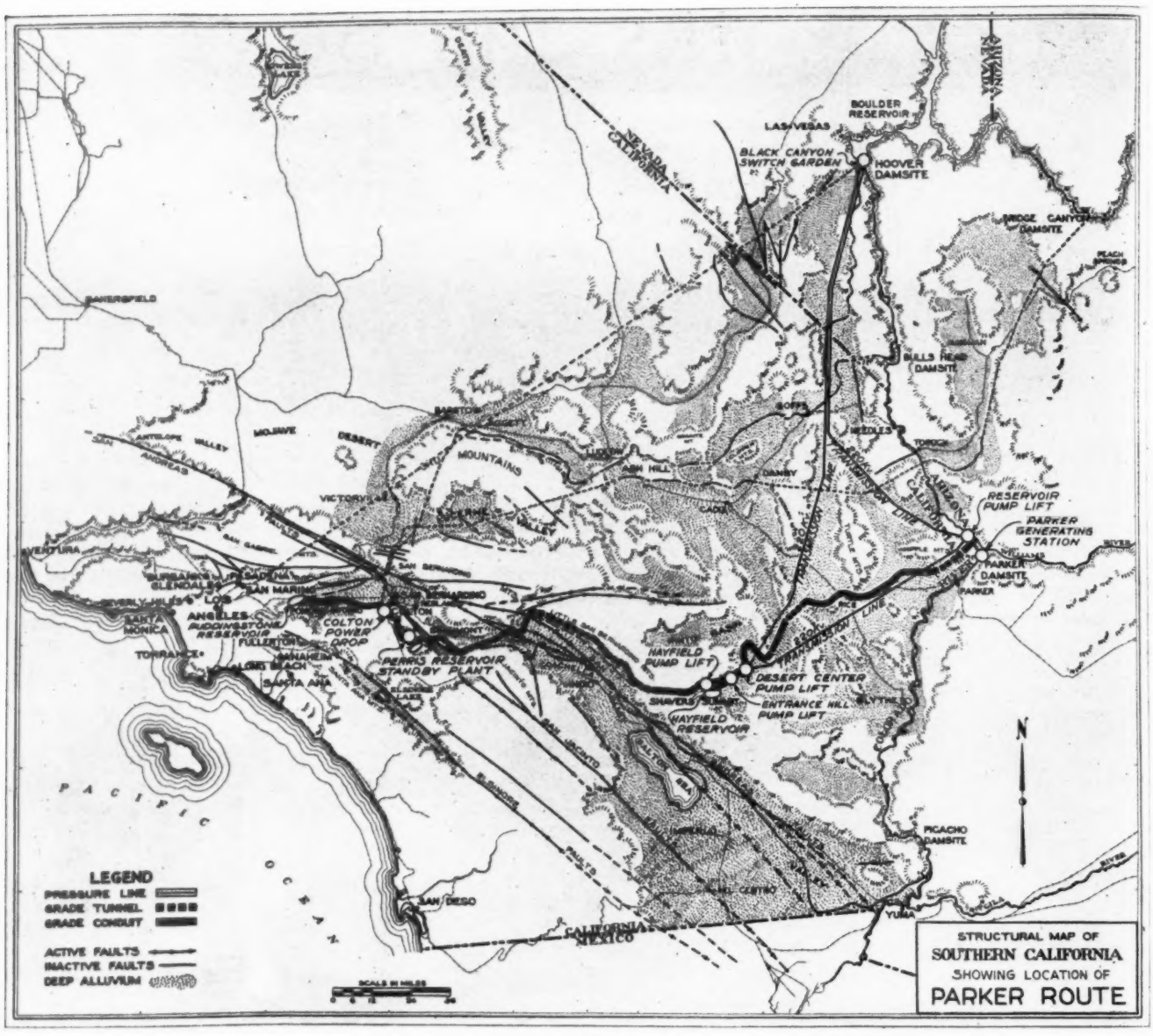
Nature of the Area to be Traversed by the Aqueduct.—The entire region between the river and the metropolitan basin is very rugged and the geology is complex. The region is composed generally of barren mountains, separated by deep valleys filled with porous debris. Some of these gravel-filled pockets, of unknown depth, have no outlets and have accumulated the scanty rainfall of past ages until they are now full of water. They are serious barriers against deep tunnels, as are the numerous faults and fissures which traverse the area.

Surface conditions in the detrital materials vary widely but generally are favorable for the construction of lined surface conduits. The mountain areas above the detrital cones are usually rugged and unsuited to surface conduit construction.

The Necessity for a Pumping Project.—The air line distance from Los Angeles to the river is more or less constant all the way from Yuma to the Hoover Dam site. The river bed elevation in this distance varies from about 600 ft. to 120 ft. above sea level. The area to be supplied from the aqueduct varies from sea level to an elevation of 1,500 ft. with limited areas even higher. Assuming that the major portions of the highest areas can be supplied from present high level sources, a fairly large percentage of the Colorado River water may be allocated to areas below elevation 500 ft. But even this level is higher than the bed of the river



Surface Conduit Country at Hayfield Dry Lake



The Parker Route Showing Locations of Various Types of Sections

at most of the possible diversion points. Furthermore, a fall of approximately 1,000 ft. is required to overcome friction in the aqueduct and distributing lines. It is therefore necessary that the water be pumped or elevated by some means at least sufficiently to overcome friction losses.

Also, the district area is separated from the Colorado River watershed by high plateaus and mountain ranges. To tunnel entirely through these high areas, at the minimum level required for the delivery of water, would be enormously expensive even if feasible. Actually, such a tunnel would be impossible of construction because of geological difficulties. The water must therefore be lifted an additional amount over the minimum requirement for delivery, to avoid expensive construction, the proper height of lift being found from economic considerations. Part of the energy required for pumping over the mountains can be recovered in fall after the summit is passed.

Certain so-called gravity routes have been studied in great detail but have not been found advantageous. They generally involve long extensions of the aqueduct, mostly in tunnel, and the construction of immensely high diversion dams. The energy theoretically saved by such lines is largely offset by power losses resulting from the diversion of flow from prospective power plants on the river. The increase in capital expenditures is out of all proportion to the possible savings.

Point of Diversion.—The fact that a considerable portion of the river is at approximately constant distance from the area to be served, permits considerable latitude in the selection of a diversion point. Prudence dictates that, other things being approximately equal, the diversion should be made where the river is confined between definite rock banks and where a diversion dam or other headworks can be constructed and maintained in operation with facility. Also, in the absence of other adverse factors, an advantage is gained by going upstream and thus securing a higher initial elevation. The location of a line from any point of diversion is controlled by the availability of low level on narrow mountain passes, the absence of wide or deep depressions to be crossed, and the topographic and geological conditions in general.

Considering the fact that in the beginning there was no particularly definite indication where the line should be located, in an area of some 30,000 square miles of rugged and at that time largely unsurveyed desert coun-

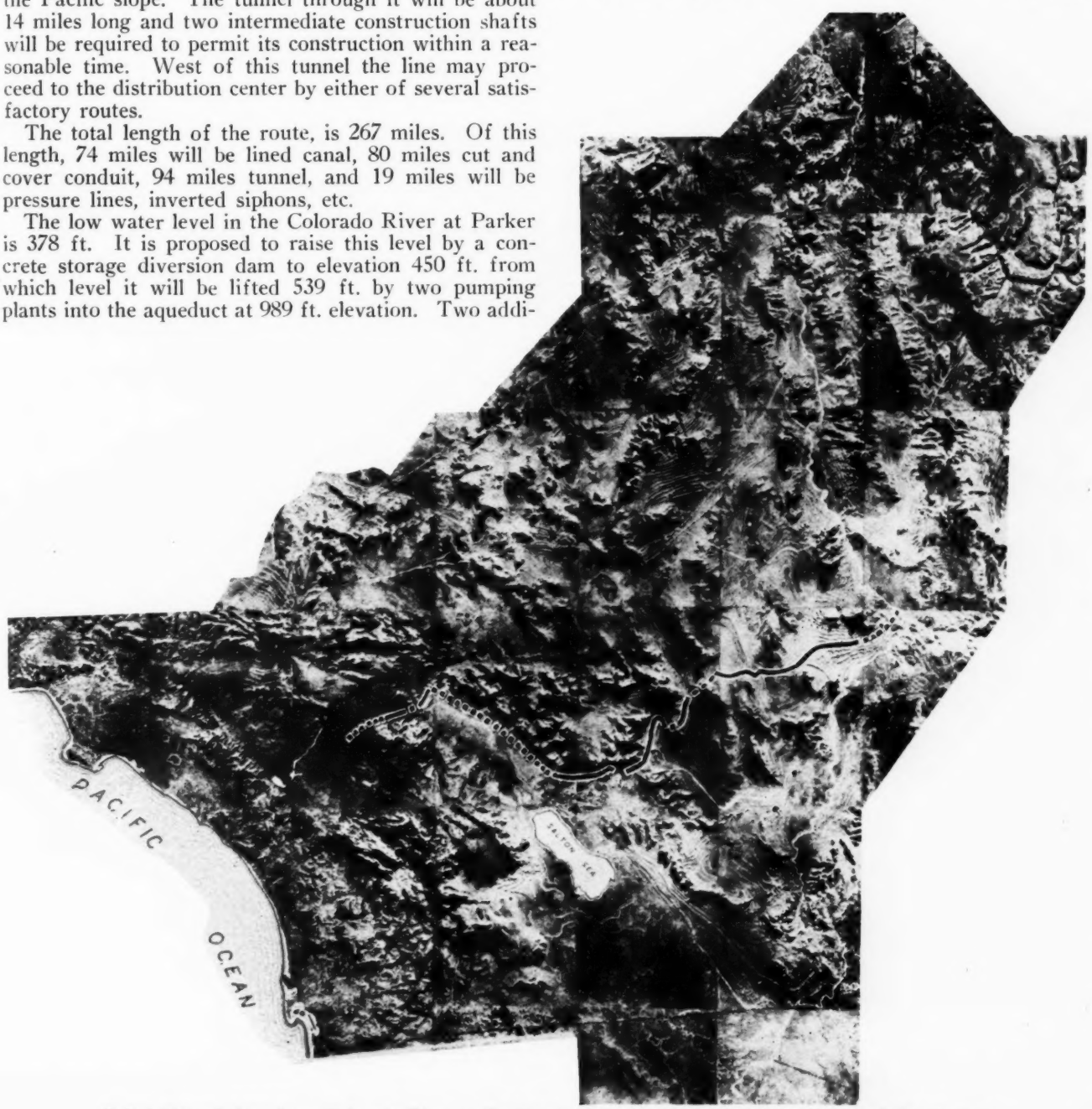
try, it will be appreciated that the problem was complicated. In its solution hundreds of lines have been projected and estimated and from the results the Parker dam site, a short distance upstream from Parker, Ariz., has been chosen as a point of diversion.

Description of Parker Route.—The aqueduct leaves the river in a steep pressure line and then goes into a series of tunnels aggregating about 12 miles in length. Then it follows a long reach of canal, interrupted occasionally by short pipe lines and tunnels, to Shavers Summit, a controlling pass. West of this summit the topography is rough and for a distance of some 40 miles the line is in a succession of short tunnels along the base of the Little San Bernardino Mountains. It then turns south across the western end of the Coachella Valley, crosses the active San Andreas fault on the surface and then goes into the longest and deepest tunnel of the line, under the San Jacinto Mountains, south of the San Gorgonio Pass. This pass marks the final divide between the Colorado River watershed and the Pacific slope. The tunnel through it will be about 14 miles long and two intermediate construction shafts will be required to permit its construction within a reasonable time. West of this tunnel the line may proceed to the distribution center by either of several satisfactory routes.

The total length of the route, is 267 miles. Of this length, 74 miles will be lined canal, 80 miles cut and cover conduit, 94 miles tunnel, and 19 miles will be pressure lines, inverted siphons, etc.

The low water level in the Colorado River at Parker is 378 ft. It is proposed to raise this level by a concrete storage diversion dam to elevation 450 ft. from which level it will be lifted 539 ft. by two pumping plants into the aqueduct at 989 ft. elevation. Two additional plants at mileposts 100 and 104 again lift the flow 497 ft. and deliver it into the Hayfield reservoir at elevation 1,367 ft. The fifth and final lift of 450 ft. takes the water from this reservoir and delivers it through the pass at Shavers Summit. The total pump lift is 1,486 ft., unless the dam at Parker is omitted, in which case the total lift is 1,558 ft. The line as described and the figures given are from preliminary locations and subject to change.

Terminal Facilities.—The locations shown for the aqueduct west of the San Jacinto Mountains are tentative and the locations of the return power drops have not been definitely decided upon. It is probable that a large amount of the flow can be dropped through a height of 400 ft. or perhaps more. The flow to the coastal areas, which will no doubt be of considerable importance, may be dropped through 800 or 900 ft. The exact location of terminal storage reservoirs is likewise yet to be determined. Ample reservoir space can be developed at satisfactory locations. A storage



Relief Map of Area from Colorado River to the Coast, Giving An Idea of the Roughness of the Country

capacity of 300,00 acre feet has been tentatively selected as sufficient for ultimate regulation and protection. Seasonal storage is available in the Boulder Canyon reservoir above the Hoover Dam, local storage being required only to care for variations in demand and for protection against accidental interruption in service. The volume and distribution of storage will also have an important bearing on the value of the power producible at the drops on the aqueduct.

Sources of Power for Pumping.—Power for pumping will be secured from the plant to be constructed at Hoover Dam. Contracts have been signed with the United States Government for 36 per cent of the firm power output of its proposed plant at 1.63 mills per kw-hr. in the falling water. An additional charge will be made for generation, making the total cost something less than 2.0 mills. There will be available at times a considerable output of secondary power and the district has contracted for as much of such power as it may need, when available, at 0.5 mill per kw-hr. in the falling water, plus the cost of generation. The power plant will be constructed by the Government but will be leased for operation to the principal contractors for power. The district has no operating lease but will secure its power from the part of the plant leased to the city of Los Angeles. Under full development the five pumping plants on the Parker route will require 291,000 kw.

It is expected that the district will construct and operate a power plant at the Parker dam. It is possible to generate 80,000 kw. at this point, all of which may go to the district, unless the dam and generating plants are constructed as a joint enterprise, in which event the power output will probably be shared with other users. In the early years of operation the firm power contracted for at Hoover Dam may be found sufficient to fully meet the district's demands, in which case it is possible that the construction of the Parker dam may be deferred for a time. Under such circumstance, deferment of the dam construction might have certain financial advantages, although these are largely offset by the cost of temporary pumping plants and clarification works required at the intake.

The power generated at Parker will be used there for pumping. Power produced at drops along the line may be used by the district for pumping in the aqueduct or distribution system, or it may be sold at wholesale, as may be found most advantageous. Provision will be made for producing such power at hours of peak demand, which is expected to add to its sale value.

Preliminary engineering work on this project is now nearing completion and final location of the main aqueduct is under way. The long tunnels, which are the controlling features as to length of the construction period, will be ready for construction by the time financial arrangements can be completed.

Investigation of the Colorado River project was begun by the Bureau of Water Works and Supply of the City of Los Angeles in 1923 and was carried on under the direction of Chief Engineer William Mulholland and his successor, H. A. Van Norman, until the spring of 1930 when it was taken over by the present district organization. F. E. Weymouth is chief engineer of the district. W. P. Whitsett is chairman of the board of directors.

Acknowledgement.—The above is an abstract of a paper presented May 27 at the 51st Annual Convention of the American Water Works Association.

Aerial View of Colorado River at Parker Dam Site

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

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Water Treatment and Purification Problems Discussed at the Pittsburgh Convention of the American Water Works Association

IF THE attendance at the various sessions of the Water Purification Division was an indication of the interest in the Pittsburgh Convention, it was the most successful meeting ever held by the Association. From year to year the Water Purification Division has demanded a larger room in which to hold its meetings. Almost every year they have been assigned a larger room than the previous year. This year the room was considerably larger than has been available heretofore, yet it was filled to overflowing. The papers abstracted below give some idea of the subjects which produced such an attractive program.

Committee on Standard Methods of Water Analysis. Jack J. Hinman, Jr., Chairman. Prof. Hinman presented a lengthy report on the activities of the Committee on Standard Methods, which indicated considerable activity on the part of the committee within the past year. The proposed seventh edition of Standard Methods of Water Analysis, in galley proof form, had been sent out to the members of the committee a few days in advance of the convention, and was brought up for discussion. The revised edition shows very few changes from the present edition. Discussions from those attending the meeting indicated general dissatisfaction with the inability of the committee from the American Water Works Association to get through more changes in the methods. There seemed to be a feeling that many good recommendations are being ignored by the Committee on Standard Methods from the American Public Health Association. It might be well for the committee from the American Public Health Association to take note of the dissatisfaction of the water works employees, who now constitute probably the majority of the users of standard methods. The committee from the American Water Works Association is largely a research committee, and most of its recommendations are based upon sound facts as a result of much research work. To have such recommendations almost ignored is producing a dissatisfaction, which if something is not done to give the Committee from the A. W. W. A. more consideration, may result in such a hostile feeling that future cooperation of the two committees will be difficult.

Tastes and Odors in Water, Causes and Remedies. Paul Hansen. Much attention has been given to the problem of taste and odor elimination in public water supplies within the past few years. This increased interest is at least partially due to an increasing public demand for water free from objectionable characteristics. Until comparatively recently most of the tastes and odors in public supplies were due to microscopic organisms. Increasing volumes of industrial wastes are now being poured into rivers used for public water supplies, and in some instances is materially increasing tastes and odors. Four methods of taste and odor removal have come into use; namely, aeration, filtration, addition of chemicals, and adsorption with specially prepared carbon. Aeration is the oldest method and perhaps has had the widest application. Spray aerators, step and cascade aerators, and diffused air aerators constitute the principal types of aerators. Aeration is effective in removing dissolved gases, but is not effective in removing dissolved substances such as phenols. Aeration has certain incidental advantages in connection with the removal of tastes, such as the removal of carbon dioxide from the water and for thoroughly mixing the chemicals with the water. Filtration is not primarily a means of removing tastes and odors, though the process of filtration greatly reduces the tastes and odors resulting from the presence of organisms. It will not be looked upon as a definite means for the removal of tastes and odors, but will be considered the main process of which taste and odor removal processes are adjuncts. The additional of chemicals for taste and odor control may be for the prevention or for the removal of tastes and odors. Copper sulphate may be added to kill microscopical growths. Super- and dechlorination is effective in removing certain tastes and odors. Ammoniation followed by the addition of chlorine is effective in preventing chlorinous tastes both as a result of industrial pollution or residual chlorine in the water. It has an additional advantage that the chloramine formed is persistent in having a continued bactericidal action. Within the past few years much attention has been given to the use of specifically prepared carbon for removing tastes and odors. Active carbon has proven effective in positively removing practically any kind of taste and odor whether due to organisms or to phenols. Active carbon functions in two ways, by adsorption and by direct chemical action. When carbon is used in contact beds it involves relatively large filter plant adjuncts. To avoid new construction it has been proposed to apply active carbon to the water in the form of a powder. There is evidence that its application is both practical and economical. There are limitations as to intensities of tastes and odors that can be handled in a practical way, but within rather wide limits water works men may now feel confident that any taste and odor problem can be solved.

Water Purification Problems in Mining and Manufacturing Districts. Chester F. Drake. The author gives the chemical and physical characteristics of water suitable for drinking purposes on common carriers as

set forth in a report of the Advisory Committee to the Treasury Department in 1925. He states that, in general, there is little difficulty in approaching these standards without excessive cost or ingenuity. Thirteen types of industries are named as producing pollution in the Allegheny River. With the wide diversity of industrial wastes, the problem of producing a municipal water supply meeting the exacting chemical and physical requirements of the consumer is difficult and expensive. Due to mine and industrial wastes, the average annual alkalinity of the Allegheny River at Aspinwall has fallen from 24 parts per million in 1909 to 5 parts in 1929. Soda ash is used at the Aspinwall plant to increase the alkalinity when it falls below a certain point. The rapid and wide fluctuation in acid content is of much consequence. A constant load might readily be cared for, but the uncertainty of a fluctuating acidity results in poor coagulation for rapid sand filters and the sterilization of beds in slow sand filters.

Manganese in Water; Its Occurrence and Removal. R. S. Weston. Manganese behaves somewhat like iron, but usually oxidizes slower than iron. Mr. Weston gives a list of 19 ground water supplies containing manganese in which it ranged from a trace to over 50 parts per million of manganese. Bjornstop, Sweden, and Breslau, Germany, have wells in which the manganese runs unusually high at times. None of the American ground water supplies run over about 4.0 parts per million. Twenty-four cities with surface supplies containing manganese were listed. Baltimore has a manganese content of 0.20 ppm. or less. The Ohio River at East Liverpool, O., contains 0.88 ppm. and the Scioto River at Columbus, O., contains 0.22 ppm. of manganese. In New Jersey, the Department of Health found the manganese in 238 potable supplies to range from 0.03 to 0.20 ppm. The presence of small quantities of manganese in water supplies would have attracted little attention except for its effect on the control of chlorine treatment by ortho tolidin. The effect of depth on the dissolved oxygen and managanese content of the Wanaque Reservoir in the Jersey highlands is interesting. The reservoir holds 28 billion gallons of water, and was filled full for the first time in March, 1929. Tests on depth samples collected July 4, 1930, are shown in the table.

Depth in Feet Below the Surface	Per Cent Saturated with Dissolved Oxygen	P.P.M. of Manganese	Residual Chlorine Blank
0	106	.00	.03
10	105	.00	.03
20	90	.05	.06
25	40	.05	.07
50	27	.06	.10
40	31	.14	.17
50	29	.36	.25
60	22	1.10	.30
70	35	1.90	.24
77	0	2.40	.15

Manganese gives trouble in laundries, coats the inside of pipes, and interfered with the bleaching of yarns. The methods of removal parallel those of iron, although not so simple. The organisms, crenothrix and manganese bacteria play an important role in the removal of manganese. In the softening process, manganese is readily removed by the lime with the aid of ferrous sulphate. It is better to depend on surface contact with accumulation of hydrate and organisms for manganese removal. Aeration, contact with precipitated hydrate and organisms in a contact aerator, followed by filtration through sand, is usually sufficient to remove manganese from water.

The Occurrence of Fluorine in Water and Its Probable Relation to the Formation of Mottled Teeth. H. V. Churchill. One of the very interesting papers presented at the convention was on the occurrence of fluorine in potable water, and its apparent relation to the condition of the enamel of teeth. Mr. Churchill stated there was so specific proof that fluorine was the cause of mottled teeth, but the circumstantial evidence indicated this to be the case when the fluorine was present over a certain amount. McKay, several years ago, found in several localities that most of the people who used the water from certain sources during the age when the permanent teeth were being formed, had teeth with defective enamel. He attributed this to some unknown constituent of the water. Bauxite, Ark., was one of the affected areas. Water was being obtained from deep wells, but was later abandoned when it was suspected of being responsible for the mottled teeth. Tests were made on this water to see if it contained some constituent not ordinarily tested for in chemical analyses of water. The presence of fluorine was detected with the spectroscope. The calcium fluoride band is quite distinct, and the presence of this compound in fairly large quantities was readily detected with the spectroscope. The deep well water contained 13.7 parts per million of fluoride, enough to etch glass when the water was made acid with sulphuric acid. The water from Colorado Springs, formerly used for a water supply, contained 2.0 ppm. fluoride. A well near Kidder, S. Dak., contains 12.0 ppm. fluoride, one near Ledgerwood, N. Dak., 11.0 ppm., and at Oakley, Idaho, 6.0 ppm. fluoride. Fluorine in small quantities was found in the water supplies of Cincinnati, Milwaukee, Birmingham, Pittsburgh, East St. Louis, Kansas City, Toledo, Cleveland, Detroit, Indianapolis, Buffalo, Davenport, San Francisco, Minneapolis, and Los Angeles. Most of the water supplies west of the Appalachian Mountains show the presence of a trace or a very small quantity of fluorine, whereas those east of the mountains show no fluorine. Fluorine was not detected in the Chicago water supply, even though it was found in most of the water supplies obtained from the Great Lakes. The condition of teeth where there is fairly large amount of fluorine show some relation between the amount of fluorine and the effect on the teeth. The condition of the enamel at Colorado Springs was not so bad as at Bauxite, Ark., and Ledgerwood, N. Dak., indicating that the higher the fluorine content of the water the greater is its effect upon the teeth. R. F. Goudy stated that a small amount of fluorine was necessary for the formation of the enamel on teeth, and related that enamel failed to form in one locality where the water and all food was free from fluorides.

Filtering Materials for Water Works. Wm. E. Stanley. The present active interest in water filter materials, and lack of knowledge of some of the characteristics of such materials, indicate the desirability of more extended research covering the various characteristics of water works materials. A committee of the Sanitary Engineering Division of the American Society of Civil Engineers has been giving the matter considerable attention for the past several years. Mr. Stanley outlined what has been undertaken, and calls attention to the need for cooperative effort amongst the various investigators. The primary function of the filter unit is to remove as completely as possible those impurities remaining in the water after preliminary treatment. The service required is more complex than that of a mere strainer. The material must have such characteristics as to permit being readily cleaned during washing. The

acceptance of chlorine as a safe and practical method of bacterial removal has reduced the function of the filter bed largely to that of producing clear water. There are times when it is impossible to obtain a strong flocculation of the coagulated materials in many waters, and it passes more readily into and through the filter beds. This brings up the necessity for study of pretreatment as an aid to filtration. The efficiency of a filter bed is measured by the output of a good quality of water at the minimum cost. The problems which occur in connection with filter sand may be classified as those relating to design and those relating to operation. It has been pointed out within the past few years that the actual effective size of filter sand in a rapid sand filter may be that of the top few inches. There are many problems affecting the operation of filter beds, such as shifting or intermingling of sand and gravel, biological growths in filter beds, films on sand grains, bacterial growths, mud balls, shrinkage cracks, incrustation, and rate of backwashing. Each problem may have a separate solution. More definite knowledge of the action of filter sands under varying conditions will assist in the proper design of filtration plants to meet such conditions. Two major lines of study might be undertaken—one relating to the hydraulics of various sands, and the other to the actual operation of the test units similar to plant conditions. The interpretation of the results will be difficult because of the many factors affecting the operation. Mr. Stanley stresses the need for greater cooperation between the designers and filter plant operators in studying filtering materials.

Filter Sand. James W. Armstrong. The experiments which form the basis of the paper were undertaken in connection with the work of the Committee on Filtering Materials of the Sanitary Engineering Division of the American Society of Civil Engineers. The experiments were conducted with filters made from glass tubes about 1¾ in. inside diameter. The filters were supported in a way that it was possible to get a maximum loss of head of about 8 to 9 ft. A filter bed should have a well graded bed of gravel and coarse sand for supporting the actual filter medium. When it was necessary to remove the sand from the large units at Baltimore, those filters were generally in best condition which had a relatively deep layer of fine gravel. Occasionally designers fail to appreciate the necessity of a well graded layer of coarse sand. In one case a large volume of sand was lost and in another case the entire sand was lost by the omission of the layer of coarse sand. A large portion of the floc lodges on the top of the filter when the sand is between 0.33 and 0.45 mm., and as the loss of head increases it is carried deeper into the filter bed. When wash water is applied the fine sand and floc in the thin crust at the top are so thoroughly compacted that the sand grains are only partially released and small matted pieces of sand and floc settle rapidly into the filter bed, where they remain and form the nuclei for mud deposits. The behavior of coarse sand is quite different, and the flocs are not broken up so finely in penetrating into the beds. During the washing period the sand is lifted only a few inches, and the grains striking each other tend to loosen the floc and carry it away with the wash water. Filter beds of coarse sand do not grade themselves hydraulically so well as the finer sand. The absence of close hydraulic grading may partly account for the long satisfactory runs obtained from very coarse grained filters. The sand grains do not rise uniformly when the filter is being washed, but are forced upward almost vertically by jets of water traveling rapidly. When the grains reach a height slightly above the level of the surrounding grains they shift to one side and settle down to a point where they are picked up again. To test the penetration of floc unto the beds, samples of sand were collected at different depths, the floc washed loose from the sand, collected, ignited, and weighed. The relation between the rise of the sand and the rate the wash water is applied is not a straight line as found by several workers, but is a curve in which the rate of expansion keeps increasing slightly over the rate at which the wash water is increased. There are two essential factors involved in the process of washing filter sand—the striking or rubbing together of the sand grains, and the secondary action due to the velocity of the wash water in passing between the grains. A filter with only the gravel added showed no displacement of the gravel when washed at a rate of 60 in. vertical rise per minute, whereas filters after a period of service washed at rates not to exceed 30 in. vertical rise showed considerable displacement of the gravel. This is believed to be due to the crust of the beds breaking at certain points when the wash water is first turned on and the rush of wash water through the breaks is enough to displace some of the gravel. Opening the wash water valves slowly until the crust is broken is believed to have remedied this trouble.

The Chemistry of Chloramines. J. F. T. Berliner, The substance produced when chlorine is added to water containing ammonia is largely monochloramine. Some dichloramine may be formed, but with the low concentrations used in water treatment the amount is relatively small compared to the amount of monochloramine formed. The use of ammonia has spread rapidly. On Jan. 1, 1930, five plants were using ammonia. Seven months later 70 plants were using this material, and on May 15, 1931, 190 plants were using ammonia. Ammonia added to the water in advance of the chlorine is successful in preventing certain types of tastes. All chlorinous tastes may be prevented when ammonia is used in the right proportion. Ammonia is successful in preventing certain types of algae tastes. Chloramines have been known for about 120 years. When pure, it is an oily liquid, and is highly unstable. All forms of chloramine are soluble in water, and the monochloramine is extremely soluble, but is insoluble in carbon tetrachloride. The monochloramine was not recognized until 1870. The chlorine has to go through the reaction with water to form hypochlorous acid before it reacts with ammonia. The work at Cleveland indicates the formation of ammonia-chlorine hydrates.

The Revivification of Granular Activated Carbon for Water Purification. Paul Mahler and H. B. Crane. All activated carbons eventually have to be revivified by heat treatment, though it may be partially revivified by other treatments several times between the heat treatments. Development of the air-heat ractivation of spent Darco is the result of research on all factors influencing revivification of such materials. A horizontal rotary tube of hyb-nickel is used. The granular material is fed into the tube at one end and passes out at the other end revivified, but it undergoes three distinct stages in the tube. As the wet spent carbon is fed into the externally heated tube, the moisture is gradually driven off. On leaving the drying zone the carbon enters what may be called the defuming stage of the process. Almost immediately after the carbon is dried, fumes, which are usually recognized by their characteristic odor, start coming off. The speed of the reaction is slow at first, but it increases enormously, giving off heat

as the critical temperature is reached. The carbon reached a temperature of about 360° C. in the defuming zone. Beyond this point no outside heat is needed. The defuming will usually restore the carbon to about 60 to 70 per cent of its original adsorptive power. The third and last step through which the carbon passes takes place in the activating zone of the tube. A carbon residue is left when the adsorbed organic impurities are decomposed. This carbon has no adsorptive power and if allowed to remain in the char, its adsorptive efficiency will be reduced. The admittance of air in sufficient amounts, at the proper temperature, will cause oxidation of all the inert carbon without burning any of the active material. One can only surmise that the oxygen has a selective affinity for the inert carbon. Materials spent in different ways have been completely restored to their original activity. One sample of Hydrodarco was spent by passing the raw water of the Mamaroneck water supply through a bed of the material, another sample was obtained from Los Angeles, Calif., where experiments are under way on reclaiming sewage water, another from the Chicago Experimental Filtration plant where it had been in continuous service for more than 2 years, and another was spent with a molasses solution. All of these samples were restored to their original adsorptive power.

A Study of the Bactericidal Efficiency of the Ammonia-Chlorine Treatment. H. H. Gerstein. A study has been made of the bactericidal efficiency of the ammonia-chlorine treatment as compared with ordinary chlorination. It is possible for some of the consumers in Chicago to receive water which has been chlorinated only about 3 minutes previously, consequently a slowing down of the bactericidal action would be of great disadvantage because of lack of protection to consumers near the pumping stations. Mr. Gerstein forms the following conclusions as a result of study of the tests:

The treatment is effective in preventing the formation of the chlorinous and chlorophenol tastes and odors which are associated with the chlorination of the water supply and is a very efficient bactericidal agent.

For the same chlorine dosage the bactericidal velocity of the ammonia-chlorine treatment is decidedly slower during the first two hours after the treatment is applied than that obtained with chlorine alone. The larger the amount of ammonia present, the greater is the lag in bactericidal effect.

For periods of contact longer than 2 hours, the final bacterial effect of the ammonia-chlorine treatment is greater than that obtained by the use of the same amount of chlorine alone. In this period the ultimate effect is greater with a larger amount of ammonia present.

By increasing the ratio of chlorine to ammonia it is possible to obtain a combination which will equal the bactericidal velocity attained after 5 minutes contact with a definite amount of chlorine without ammonia. This ratio of chlorine to ammonia, however, will not prevent the formation of chlorophenol tastes and odors.

The temperature of the water has a marked effect on the bactericidal efficiency of the treatment, the efficiency being greater with increasing temperature within the range of the experimental work, 0° to 20° C. An increase in the turbidity of the water decreases the bactericidal efficiency.

Combating Tastes in West Virginia Public Water Supplies. E. S. Tisdale. There were 14 types of tastes reported by the various plant operators in West Virginia during the past year. All methods of taste elimination were tried. In some instances they were successful, in others the tastes were not completely eliminated. Superchlorination, ammonia-chlorine, prechlorination, permanganate, and powdered activated carbon were some of the treatments tried. Water was so scarce it had to be hauled by rail to several cities. The flow of the Elk River at Charleston, W. Va., fell below the city's need in August, 1930, and then the Kanawha River carrying excessive high organic content from garbage putrefaction flowed up the Elk River to the intake. A heavy growth of algae occurred, and this together with the pollution gave the water a woody, mouldy, disagreeable taste. Various methods of taste elimination were tried. In addition to the usual coagulation, sedimentation, filtration and chlorination, the water was prechlorinated and aerated. Chlorine as high as 20 lb. per million gallons was tried. Permanganate, ammonia-chlorine, superchlorination, and powered activated carbon also were tried. None of these treatments removed entirely the taste and odor. A widespread epidemic of intestinal disorder occurred in October and November, 1930, in which it was estimated that 8,000 to 10,000 were affected. Acid mine waste improved conditions in one river by preventing growths. Morgantown tried the ammonia-chlorine treatment, and powdered activated carbon. Along the Ohio River, Weirton tried permanganate, and the ammonia chlorine treatment. Tastes developed in the well supply of Moundsville where it had never occurred before. This was remedied by the ammonia-chlorine treatment.

Ammonia Salts in Taste Elimination. Harry E. Jordon. The ammonia-chlorine treatment was tried, first to eliminate certain tastes that occasionally occurred in the finished water at Indianapolis, and to prevent bacterial aftergrowths in the sedimentation basin of the slow sand plant. Preammoniation was started in September, 1930, using anhydrous ammonia. On Oct. 20, 1930, use of ammonium sulphate instead of the anhydrous material was started and has been continued up to the present time. Anhydrous ammonia costs 17 ct. per pound, and ammonium sulphate 10.4 ct. per pound of NH_3. The ammonia content averages about 25.5 per cent. Phenol is found to the extent of 0.003 per cent. This is only about 1/67 of the minimum taste-producing amount. The sulphate stores well, and is capable of being fed through a dry feed machine. At Indianapolis it is mixed with the aluminum sulphate. The alum and ammonia are fed into the water about 10 seconds in advance of the chlorine. The ammonia-chlorine ratio is about 1 to 2.25. Mr. Jordon believes the procedure of operating on a treatment in which the ammonia is all added first and the chlorine applied at two points is not the best procedure. There is no assurance the ammonia first added will reach the second point of chlorine application. The second application of chlorine will then be just a straight chlorination. The use of ammonia unquestionably improved the taste during the winter, and chlorinous or musty tastes have not been present. The bacterial efficiency of the plant has been increased.

Results of Taste and Odor Control With Ammonia-Chlorine Treatment at Beaver Falls and New Brighton, Pa. E. C. Goehring. Beaver River fluctuates widely in chemical characteristics. During the past 5 years, various treatments have been tried to eliminate tastes, which were largely from by-product coke plant, with little success. Two filtration plants are operated by the Beaver Valley Water Co. An ammoniator was installed in one of the plants in March, 1930. The ammonia treated

water was far more palatable than the pre and post-chlorinated water. Residual chlorine appeared in all parts of the distribution system where the ammonia treated water was pumped, whereas in the other supply it vanished shortly. It was necessary to carry a residual of 0.20 ppm. immediately after chlorination to get satisfactory sterilization of the water in 2 hours when ammonia was used. When the ammonia was applied to the raw water, reductions in the ammonia content of the water were found. There was a reduction of 5 to 25 per cent in passing through the sedimentation basin, and from 40 to 60 per cent in passing through the filter beds. This makes a total reduction of from 40 to 70 per cent. The ammonia loss may be reduced by adding chlorine shortly after the ammonia. The treatment has proven valuable in minimizing chlorophenol tastes and odors. It also is an effective means of combating algae growths in basins and on filters. With sufficient contact time, the ammonia-chlorine treatment is a more efficient sterilizing agent than chlorine alone. When the chlorine demand of the raw water is low the best method is to apply the ammonia and the chlorine to the raw water.

A Resume of the Ammonia-Chlorine Treatment at Cleveland. W. C. Lawrence. This paper was largely bringing previous accounts of the use of ammonia and chlorine at Cleveland up to date. The treatment continues to be successful in removing or preventing all tastes in the Cleveland water. There is no difficulty in maintaining a sterile water throughout the entire distribution system with the ammonia-chlorine treatment. It has proven entirely satisfactory, and has added only slightly to the cost of treating the water.

Laboratory and Plant Results with Activated Carbon at Bay City's Filtration Plant. L. B. Harrison. Tastes and odors at Bay City are dependent largely upon wind directions, and are liable to appear suddenly. The tastes are in the raw water and are not as a result of the addition of chlorine. Other taste elimination treatments, such as the ammonia-chlorine, superchlorination, and permanganate, were not successful in entirely eliminating the taste. By having excess capacity in the filter plant, some of the filter beds may be used for carbon units. The sand was removed from one of the filters and it was filled about 2 ft. in depth with granular Hydrodarco. The rated capacity of the filters are each 2 million gallons daily. The filtered water is pumped from the effluent of the other filters up to the carbon unit. It is planned to fill one or two more units with carbon when the water consumption increases. The carbon unit now in service is not operated continuously, but used only when the filtered water has a taste or odor. This is the largest activated carbon unit for water treatment in America. The carbon has successfully removed all tastes and odors in the Bay City water.

Experiences with Powdered Activated Carbon. Malcolm Pirnie. The use of powdered activated carbon is spreading rapidly. This material is now being fed into the water at all points from the mixing basins to the filters. Amounts ranging from 0.1 to over 1.0 grain per gallon are being used. When applied directly to the filters runs are shortened materially. At most places where it has been used it has been successful in removing the tastes and odors. In one plant where the powdered material did not remove the taste, it was removed by passing through a bed of granular activated carbon. Powdered activated carbon is a cheap and efficient means of removing tastes and odors from water.

104-Year-Old Water Pipe Unearthed

A section of the oldest cast iron water pipe in the United States was excavated at Philadelphia on May 1. This pipe was laid over a century ago and has served the city ever since without interruption.

An examination of the pipe showed it to be in excellent condition and still capable of functioning for an indefinite period. This pipe is a part of the system which the city started to install in 1817. Prior to that time all water mains in Philadelphia and, in fact, in the country, were of wood. The water committee had decided just after the year 1800 to make a study of better water carrying facilities and as a result decided to import from England a small quantity of cast iron pipe to be laid as an experiment. The results were so satisfactory that from time to time iron pipes were laid to take

104-Year-Old Pipe Unearthed at Philadelphia

the place of wood. The pipe excavated is a piece of the early pipe imported from England.

The pipe is of the bell and spigot type and is in 9-ft. lengths. A curious feature of these pipes which was mentioned in a paper before the American Society of Civil Engineers in 1914 by Marshall R. Pugh, C. E., is that each length has three or four rings about it, approximately 1½ in. wide, which were presumably to afford places with heavier walls in which to tap the pipe. Although these original pipes are now only an infinitesimal portion of Philadelphia's present great system, nevertheless they still constitute a considerable mileage.

WATER WORKS IN TENNESSEE—According to the report of the State Department of Public Health of Tennessee for the fiscal year ended June 30, 1929, there were 153 public water supplies in the state. Of this total 81 were municipal plants and 72 were privately owned. A total of 67 water works employed no treatment, 42 had disinfection alone, 35 had complete rapid sand filtration plants, including disinfection, one employed coagulation, sedimentation and disinfection, and 8 had iron removal plants.

SAN FRANCISCO TO HAVE CHIEF ADMINISTRATIVE OFFICIAL.—An interesting feature of the new charter adopted by the voters of San Francisco on March 26 is the provision whereby the mayor appoints a chief administrative officer who will have charge of several of the important departments of which he appoints the heads.

The Operation of Trickling Filters

Part II of an Article on This Subject. It Covers the Interesting Phases of Operating Difficulties. Part I, Dealing with the Theory and Operating Practices, Appeared in the May Issue

By MORRIS M. COHN
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THE operator with the vivid imagination may often gnash his teeth over his inability to control, to greater extent, the complex bio-chemical process that gives the trickling filter its oxidation efficiency and its ability to remove the hard-to-get solids from the settled sewage. It is somewhat of a challenge to the scientist that he must content himself with delivering to the bacterial circus populating the acres of stone beds, a sewage which he has freed from as much solids as possible, and then to have to trust to temperamental agencies which he cannot even see, to put the finishing touches on the treatment process.

If he feels that he has, therefore, no responsibility for the results, he will soon discover that the difficulties of operation give him sufficient worries to compensate for the care-free attitude he may assume.

Surface Clogging and Pooling.—The nice, clean stone that was laid down by the contractor who built the plant does not long remain in the condition in which the rugged jaws of the crushers left it, nor would this be desirable. The beds develop a heavy film growth which increases in thickness and perhaps goes through a most interesting color cycle. But the excessive development of this mat, just as does the deposit of solids or heavy grease in the interstices of the stone, often results in surface clogging, the pooling of large areas of sewage on the bed surface and the cutting off of valuable air circulation down into the beds. This surface condition is unsightly and produces marked decreases in nitrification efficiency.

The filter that has all of the characteristics of a wading pool can no longer be contenanced in sewage treatment practice. Where the pooling is caused by the carrying-over of clogging solids and sludge from the settling tanks, this condition points an accusing finger at the lack of attention given these units. Whatever the cause, the condition should be cleared. Picking up the stone around the pooled spots, the use of pressure water streams for mechanical scouring of the surface and even the removal and washing of such of the filter stone has been found necessary. Shutting the beds off during a hot, dry spell, allowing the beds to drain and to dry in the sun, will often result in the curling up and peeling of the gelatinous films from the surface stone and the consequent reduction in pooling. The use of copper sulphate has been suggested for the destruction of this troublesome material.

The use of chlorine to overcome and prevent filter pooling has advanced beyond the experimental stage. The Schenectady works was the first installation in this country to discover that liquid chlorine, applied to the filter influent in sufficient quantity, would destroy the gelatinous film on the surface stone, and that the consequent washing action of the sewage spray would remove this oxidized material and remedy pooling. The Schenectady findings were somewhat of an accident and in this respect, at least, have much in common with the most valuable scientific discoveries of all times. It was during a heavy chlorination study to determine the effect of liquid chlorine applied to a filter unit on the psychoda alternata filter fly, that it was found that the heavy, black shiny surface gelatine took on a grey, crumbly appearance. At rates of application of 10 p.p.m. of chlorine to the tank effluent in the dosing

All Maintenance Joys Cease in the Northern Winters When the Worker Must Skid over an Icy Bed

tanks, the sprayed sewage started to bleach out the film where it hit the stone and at higher rates of application the film was completely destroyed and the beds were left with the surface stone completely cleared of this deposit. Repetition of this effect was successful at rates of 25 p.p.m. of applied chlorine. Surface pooling was impossible under such conditions of the filter area. It is interesting to point out that the heavy film on the stone just around the nozzles was not easily removed, perhaps due to poor dosage of this area because of the quick rise to full head and the sharp cut-off of the siphon at the low discharge heads. This difficulty was remedied by throttling the inlet gates on the distributor mains so that the nozzles just dribbed the heavily chlorinated sewage over the desired area.

"The Chap Dressed Up in Storm King Boots, Rubber Slicker and Rubber Gloves, with Cleaning Hook in Hand, Touches Up the Clogged Nozzles."

The effectiveness of chlorine in clearing up badly pooled trickling filters has been shown at several installations within the past few years. Splendid picture of "before and after" have been taken to preserve the miraculous history for unbelieving man. The simplicity of the method, and the possibility of it saving badly pooled filters from scraping or from costly cleaning procedures, makes chlorination a boon to the plant operator.

Nozzle Clogging.—For a rapid survey of the efficiency of plant operation, look to the condition of the filler nozzles. Not only does the woeful appearance of completely plugged or the rakish aspect of partly clogged devices show that the beds are lacking in maintenance, but the condition of the spray nozzles is often a tell-tale of tank efficiency.

My men say that you'll find everything but money in filter nozzles and they are correct. The non-settling solids that leave the tanks with the effluent, strings of gelatine from the inside of the distributor barrels, grease growths in the nozzle domes, weeds and grass that blow into the effluent channels of the tanks and dosing tanks, animal life such as rats, mice, frogs, chunks of sludge —all these materials give work to the filter attendant. It can be seen that the care shown in tank operation is directly reflected in nozzle clogging records. The most human and most illustrative experience I ever had was associated with this business of keeping the filter sprays in neat appearance. During the course of events, one of my tank men had a misunderstanding with the chap that dresses up in storm king boots, rubber slicker and rubber gloves and goes out onto the filters each morning, cleaning hook in hand, to touch up the clogged nozzles. Animosity grew to strong that the tank man devised the clever expedient of using his skimmer to push all floating solids into the effluent channel, and make more work for his co-worker on the beds. The nozzle man had the trying experience of finding a whole bed of nozzles badly plugged just after he had left the unit in perfect condition. Manslaughter was prevented at the sewage-works only by quick action on my part in putting an end to the tank operator's little revenge scheme.

It is interesting that the application of hypochlorite and liquid chlorine to the beds through the tank effluent does much to free the distributors of organic growths and the nozzle domes and spindles of the greasy film that cuts down the effective area of discharge. The application of chlorine at Schenectady resulted in a more uniform-shaped spray and the increase in wetted stone area.

The installation of quick-opening gates at the ends of the distribution laterals will do much to keep these lines free from debris and will improve nozzle operation. Many types of nozzles are on the market today. Intelligent choice of the nozzle with the correct discharge characteristics will do much to provide optimum distribution for each individual installation.

The care of nozzles may be pleasurable during the hot days of the summer, when the cool sewage plays comfortingly around the maintenance man's legs, but all joy ceases in the northern winter when the worker slithers and skids over an icy bed, climbs over high mounds of ice surrounding the nozzles and then finds that the sub-zero temperatures of the night before have frozen the spray device solid.

The nozzle man must be a meat carving expert to clear the nozzles of the rodents and frogs that become stranded there. Our most surprising experience came

Spraying the Walls of Filter Galleries Kills Many Psychoda

the day after we had spread poisoned bait around the plant in a rat control campaign. That fatal morning, we had to remove the domes of scores of nozzles to get out the rats which had evidently jumped into the dosing tanks in search of water. Moral: beware of the thirst-producing rat poison unless the tanks and dosing chambers are covered.

Odor Control.—The trickling filter has been condemned many times as a neighborhood nuisance because of the odors that are wafted from it. This phase of filter operation has filled the court records with testimony of the gruesome, noxious odors that disturbed the health and comfort of a long-suffering public. Despite the fact that many of these odors originated in the im-

agination of the complainants rather than on the filters themselves, it must be admitted that the trickling filter is the most dangerous odor broadcaster on the treatment works site.

Filter odors may have their origin from the hydrogen sulphide gases released from the applied sewage by the breaking up of the liquid in sheets, or globules by the nozzles or the impinging action on the stone beds or from the gelatinous worm-laden film on the stone beds. The solution of the first odor problem is to keep the sewage applied to the beds in fresh condition and the hydrogen sulphide-content at a minimum. The prevention of heavy gelatine growths on the bed surface will do much to prevent the sea-weedy or fishy odor that comes from this complex material.

Several methods for reducing the odors incident to the spraying of sewage over the vast acreage of filters have been tried. The most successful method still seems to be the application of liquid chlorine, as prechlorination of the crude sewage entering the works or as post chlorination of the tank effluent in dosing tanks, just as it starts for the filter units. Again, in this field, the Schenectady works performed the pioneering work in this country. The same chlorination studies of 1925 that led to the discovery of the bleaching effect of this material on the stone gelatine, resulted in knowledge of the odor control benefits of chlorine. At that time, the application of liquid chlorine to the tank effluent at rates of from 4 to 6 p.p.m. resulted in an unexpected reduction of the characteristic filter odors. At rates of a few parts per million more of chlorine, a clean chloro-substitution product odor was noticed about the whole works that was distinctly evident to the nozzle attendant and was remarked by all visitors to the works. This "clean" smell was noticeable within a few minutes after the chlorine was applied to the tank effluent.

Later studies indicated that the application of chlorine in similarly low dosages, to the raw sewage entering the tanks, resulted in a tank effluent that gave almost the same pleasant odor reduction on the beds after some three hours of detention. Application of chlorine at rates of 6 p.p.m. to the sewage flow at a pumping station two miles above the treatment works reduced the hydrogen sulphide content of the filter spray to such extent that the men at the works could guess when the chlorinator was operating far up the line. It is pertinent that at no time during these studies was a residual chlorine available in the tank effluent and hydrogen sulphide was present in some quantities in all samples of filter influent tested. The effectiveness of this odor control process does not, therefore, depend on residual chlorine. It is highly possible that the chloro-odors produced were masking the hydrogen sulphide odors that were present.

This odor control method opens up possibilities for non-nuisance operation for plants that are afflicted with odorous filters. It must not be assumed that control will be as effective with low chlorine dosages at all installations as at Schenectady. Applications of many times the chlorine used there may be necessary for successful control work. It must be remembered that odor control work may be necessary only during certain seasons of the year, during certain days of these troublesome months and during a few hours of these dangerous days. The alert odor-chaser will determine the effect of temperature, humidity and wind movements on his plant's odors and be guided in his control work thereby. We have been carrying out observations on the effect of humidity and barometric pressure changes in odor production and it may be possible to regulate odor control efforts scientifically on the basis of barometer and psychrometer readings.

Anything that reduces the amount of film on the filter stones will aid in reducing the pungent "fish-market" odor that emanates from this material. As can be seen, the removal of this gelatine by chorline or by such other chemicals as hypochlorite of lime or copper sulphate will improve odor conditions. The resting of the beds for short periods and the sloughing-off of the surface mat will result in fresher conditions but there is some danger of marked odor production during the drying-out period.

Fly Control.—All the troubles incident to the operation of trickling filters are as sweet nothings when compared to the fly control measures required. If the gods of the sanitation world made the trickling filter, the devil must have supplied the millions on millions of psychoda alternata, or grey moth flies. The only aim in life of these unwelcome guests in the beds seems to be the production of countless progeny to carry on the fly traditions. Unwelcome as they are in the beds, the operator hates to see them pick up and leave in clouds that resemble a dense smoke. These flies are a challenge to the art of sewage treatment. Despite all the years of operation of filters, no truly successful method of fly destruction has yet been reported.

The undesirable expedient of flooding still stands out as the best of a bad lot of control measures. The periodic inundation of the entire beds, for periods of 24 hours or less, certainly does little good to the nitrification efficiency of the units. Many operators report but little nitrification loss from bi-weekly flooding, but the Schenectady installation seems more easily upset than the hardier filters of our co-experimenters. Flooding is recognized as a rapid destroyer of the adults captured in the beds, and also kills and washes out the pupae from the stone. The larvae are apparently unharmed by the flooding because of their ability to carry small bubbles of air on their breathers to supply their needs during the period of inundation. Many larvae are, nevertheless, loosened from the stone and mechanically washed out of the beds. Flooding of beds has been proven to be most effective at Schenectady on cool evenings when the air movements are strong enough to discourage the flies from attempting to leave the beds.

At Schenectady, the application of hypochlorite of lime to the filters once weekly in sufficient quantities to give a chlorine dosage of over 200 parts per million resulted in a distinct decrease in adult fly life. No larvae counts were made. The application of liquid chlorine to the filter influent at rates of 25 parts per million for 24-hour periods, repeated bi-weekly during an entire summer, resulted in the bleaching out and removal of the surface gelatine and a marked reduction in larvae found on the stones. Reduction in adult fly life was noted about five days after each chlorine application. The psychoda increased rapidly thereafter and the repeat treatment after two weeks was as necessary as it had been while the flood control methods were being applied. It is now generally agreed that the first reports to fly reduction at Schenectady, as a result of chlorination, can be duplicated. It is still true, nevertheless, that no complete control can be obtained by any of the known methods.

The auxiliary use of spray on walls and other rendezvous of the flies has proven to be of value in any fly control campaign. Pyrethrum extract in kerosene, para-dichlorbenzene mixtures and crude carbolic mixtures have proved effective at Schenectady. The use of such methods to supplement bed flooding result in

the destruction of most of the flies that elude the submergence. The flies often take refuge in tall grass about the filter site and there defy destruction. We have even taken to burning this grass and using a gasoline torch to singe the flies down near the roots, in a desperate effort to kill off these "hooky-players."

Even the tempting theory that the presence of Archortus viatcus in the filters would result in complete fly destruction has not proven true in practice. The Schenectady plant developed a large population of these insects in a test bed that had been subjected to heavy chlorination and the little fellows were gathered up during a bed flooding and sown into all the three dosing tanks and thus sprayed onto the entire three acres of filter area. Despite the rapid growth of the Archorutus and the cleaner stone evident at points of heavy population, the flies still produce billions of ancestors each year and go their way unharmed.

Fly control remains an unsolved problem. It is the most disheartening pursuit of the conscientious operator. Kill one psychoda and millions come to the funeral. Obtain a 90 per cent kill and still millions of these pesky flies wing around the filter or roost comfortably on gallery walls and in the tall grass.

Conclusion.—I trust I have proven that the trickling filter is leading the double life of Dr. Jekyl and Mr. Hyde. Surely, it has the ability to do a good job of stabilizing settled sewage at a minimum operation and maintenance cost. Serious application to the study of control possibilities has resulted in the determination of corrective measures for most of the devilish little habits of the beds. There is yet room aplenty for research. The operator who devises methods for the destruction of fly breeding in trickling filters will win the regard of all the well-behaving aerobic bacteria in the media and will find his name inscribed in the sewage-works hall of fame.

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Municipal Sewage Disposal Works a Nuisance

A decision of interest to city officials was handed down on Feb. 4 by the Texas Commission of Appeals, in the case of the city of Wylie et al. v. Stone (34 S. W. (2d) 842). *Public Health Report* for April 3 discusses the case as follows:

The plaintiff in the trial court was the owner of a tract of land which was located near the city of Wylie and which was used by the plaintiff as a homestead for himself and family. Adjacent to this land was a tract owned by the city of Wylie and on which was maintained a municipal sewage disposal plant. On the ground that such disposal plant constituted a nuisance which interfered with the use and comfortable enjoyment of his premises, the plaintiff brought suit solely to restrain the city from the further operation of the plant at the place where it was located. The jury found that the operation of the plant constituted a nuisance which diminished the value of plaintiff's premises to the extent of $5,000, that the removal of the plant by the city would entail a loss upon it of $8,000, and that there was another more suitable location for such a plant where injuries similar to those suffered by the plaintiff would not be inflicted upon others. Upon these findings the trial court decreed that the disposal plant be abated as a nuisance, and the city was restrained from using or operating the same at the place where located after six months from the date of final judgment. The court of civil appeals reversed the judgment of the trial court, and the plaintiff took the case to the commission of appeals.

By article 1109b of the Revised Statutes, 1925, cities and towns of less than 5,000 inhabitants were given the power to "appropriate private property for public purposes whenever the governing authorities shall deem it necessary and to take any private property within or without the city limits for any of the following purposes, to wit: * * * sewer systems, storm sewers, sewage disposal plants, drains, filtering beds and emptying grounds for sewer systems." The city challenged the power of the trial court to substitute its judgment as to a proper location for a disposal plant for that of the city's governing body, in the absence of pleading and proof that the city officials in locating the plant acted arbitrarily or capriciously. The commission of appeals held that the above-quoted statute vested a discretionary power in the governing body of the city as to the location of the disposal plant, and that, such being the case, the courts were not authorized to interfere with the exercise of the discretion thus granted in the absence of pleading and proof, which was wanting in the instant case, that the action of the city officials in selecting the particular location was not the exercise of a fair discretion but was the result of an arbitrary or capricious choice upon their part.

The commission of appeals also held that article 1108 of the Revised Statutes, 1925, which authorized a city to purchase and own lands for the purpose of operating a sewerage system, should be construed in connection with article 1109b, as both related to the same subject matter. The commission stated that "the authorization in article 1109b to 'take any private property' when 'the governing authorities shall deem it necessary' shall be construed to include that taken either by purchase or through condemnation proceedings. * * * No sound reason can be advanced as to why the legislature would vest a discretion in the city authorities as to the location of a sewerage plant where land was acquired by condemnation and deny such privilege where litigation had been avoided by acquiring the land by private purchase."

The judgment of the court of civil appeals was affirmed.

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State and Municipal Bond Election Results During May

New state and municipal bond issues approved by the voters of 109 communities during May totaled $68,818,172, as compared with $56,823,676 in May, 1930, according to *The Daily Bond Buyer,* of New York.

During the same period the voters of 41 communities in 20 states rejected proposals to authorize new issues totaling $4,328,914, as compared with $21,205,500 in May, 1930; $11,557,292 in 1929, and $17,841,000 in 1928.

The following table, compiled by *The Daily Bond Buyer,* presents a comparison of bonds approved by months for the past three years:

	1931	1930 (.000 omitted)	1929
January	$ 8,326	$ 11,620	$ 26,950
February	48,300	17,861	13,309
March	46,610	33,741	22,154
April	17,587	45,325	37,963
May	63,818	56,823	61,882
June	.....	13,414	53,711
July	.....	14,628	35,895
August	.....	3,369	16,540
September	.....	8,590	85,308
October	.....	4,136	21,760
November	.....	405,976	48,499
December	.....	10,461	17,002
Total	$189,643	$626,059	$420,995

Diversion of Water Works Funds

A Preliminary Statement by the Chairman of the A.W.W.A. Special Committee Emphasizing the Scope of an Investigation of One of the Most Important Problems in the Municipal Water Works Field

By HOWELL WRIGHT

Attorney and Formerly Director of Utilities, City of Cleveland, O.

ORGANIZED communities endeavor to secure an adequate supply of water, as a rule, either through municipally owned and operated water works, or those controlled by private capital. Some expression, at least of the political wisdom of municipal ownership of water works, which is a question for the state legislatures and not the courts, may be found in the fact that of the more than 9000 water works in this country supplying not less than 10,000 communities, only 30 per cent are privately owned while 70 per cent are municipal. In this brief discussion we consider only municipal water works.

It seems to be a fixed principle that the legislature may delegate to municipalities the right of regulation and control of water works owned and operated by the municipalities. The extent to which such power has been granted in the various states and the applicability of public utility acts to municipal corporations which own and operate water works are subjects in themselves for special investigation.

Governmental Function or Private Business.—In the exercise of this delegated authority it is important for us to inquire and to know in what capacity the municipality acts. Does it act in its proprietary or governmental capacity? Is a municipal water works a public utility or a governmental function?

In general we find that "the construction, operation and maintenance of public utilities by municipal corporations for the benefit and convenience of their inhabitants ordinarily constitute the exercise of private powers." (C. J. 43-551) It is also generally held that a city, in the operation and maintenance of a water works system, acts in a proprietary and not in a governmental or legislative capacity, although it has been held that this rule applies only where water is supplied for the use of its inhabitants. (C. J. 44-2304) We cite a few cases for purposes of illustration.

In a Pennsylvania case (31 Pa. 175, 183) it was held that "the supply of gas-light is no more a duty of sovereignty than the supply of water. Both these objects may be accomplished through the agency of individuals or private corporations. . . . They stand upon the same footing as would any individual or body of persons upon whom the like special franchises had been conferred."

In a New York case, however, Swanberg vs. New York (123 App. Div. 774, 775, 108 N.Y.S. 364) we read, "while it is true that the city . . . in delivering water to private individuals acts in a sense as a private corporation, yet the duty and obligation of the municipality to afford fire protection and to safeguard the public health through a pure and wholesome supply of water makes the maintenance of the water system more of a duty owing to a public or municipal corporation." The same doctrine is expressed in David vs. Portland Water Committee, 14 Oregon 96, 123. 12 P. 174. In the same breath, however, we read in an Illinois case (Eastern State Normal School vs. Charleston, 271 Ill. 602, 111 N.E. 573) that "although the business is carried on for the public advantage and is impressed with a public use, in supplying water for the use of its inhabitants for domestic and commercial purposes, a municipality is not exercising a governmental power but acting as a private corporation."

From these few citations it can be seen that this question is not always an easy one to determine. It has been declared to be a "relative question in David vs. Portland Water Committee (14 Or. 96) in the following language. "Public parks, gas, water and sewage may ordinarily be classed as a private affairs, but they often become matters of public importance, and when the legislature determines that there is a public necessity for their use in a certain locality, I do not think they can be designated as mere private affairs. That is a relative question," says the court. We may also add, however, that it is a question in its manifold ramifications for further study and investigation regardless of the opinion stated in 19 Ruling Case Law, Section 69, Water Works, that, "It is almost universally conceded that the operation of a water works system, by which a supply of water is brought into a town and distributed by means of pipes to the residences and places of business of the inhabitants, is undertaken by a municipality in its private or proprietary capacity."

Discrimination.—It is a well established rule that neither public nor private corporations may discriminate between members of the public with reference to rates and terms of service. This no longer admits of controversy.

Acting is a proprietry capacity a municipality operating a utility has the same freedom of action as private utility corporation but it is also subject to the same restrictions as to practice of discrimination in rates and service. "A municipal corporation," then, "operating a water works for profit is . . . like a private corporation engaged in the same business, bound to supply water at reasonable rates, and is subject to the control of the legislature in determining rates in the same manner as a private corporation." (19 R.C.L. Page 765)

For purposes of illustrating the rule just laid down we cite here several decisions from different states and which we hope will also show how "discrimination" is related to our subject. The cases cited deal with free service furnished by municipal water works. It seems hardly necessary to refer to such service by private water companies, as free service has been largely eliminated from the operation of privately owned water works. And it may be said with authority that while there are some court decisions which support the right of a municipality, in operating a public utility, to give free or reduced rates to public, charitable or religious institutions or for public purposes generally, the commission rulings are generally to the contrary, holding that such free and special rates are unjustly discriminatory. We are of the opinion that there is no such thing as "free service" or "free water." It must be paid for by someone.

Supreme Court Decisions.—In an Oklahoma case (1916) Fretz vs. Edmond 66 Okla. 26, L.R.A. 1918 C. 405, the Supreme Court held that the donation of water by a municipality to a state normal school did not constitute an unjust discrimination against a citizen, taxpayer, and a water consumer of the city who was required to pay a fixed rate for water used by him.

We find in a Pennsylvania case, 1922, Consolidated Ice Co. vs. Pittsburgh 274 Page 538 (118 Atlantic 544), that the fact that a municipality operating a water plant supplied itself with free water for fire protection, etc., and also supplied water free to certain public charities was not an abuse of discretion and afforded its pay customers no ground for complaint. In the case of East Illinois Normal School vs. City of Charleston (271 Ill. 602 111 N.E. 573), however, the Supreme Court held that the city of Charleston has no implied authority to undertake to furnish water from its municipal plant to a public institution for 50 years at a nominal cost, in consideration of its location in the city.

One of the most important Supreme Court cases on the subject of free water is Board of Education of Columbus vs. the City of Columbus, Ohio, Number 20903 decided April 4, 1928. The question of "discrimination" is not raised but the decision deals with constitutional questions as follows:

1. It declares unconstitutional and void as a violation of the rights conferred upon municipalities by Section 4 of Article 8 of the Ohio Constitution, a section of the General Code, which prohibits a city or village or the water works department thereof from making a charge for supplying water for the use of public school buildings or other public buildings. (It overrules a previous contrary decision. 112 Ohio State 607.)

2. It declares that section of the General Code as unconstitutional and void in that it results in taking private property for public use without compensation therefor in violation of Section 19, Article 1 of the Ohio Constitution.

3. Municipalities devise the right to acquire, construct, own, lease and operate utilities the product of which is to be supplied to the municipality or its inhabitants from Section 4 of Article 18 of the constitution and the legislature is without power to impose restrictions or limitations upon that right.

By virtue of this decision, the decision of the Supreme Court in the case of Village of Euclid vs. Camp Wise Association (102 O.S. 145) and the case of the City of Cincinnati vs. Roettinger, a taxpayer, (105, O.S. 145) the law in Ohio with respect to free water is as follows:

1. Surplus revenues derived from water rents may be applied only to repairs, plant extensions, interest and to the liquidation of indebtedness, if any, and cannot be diverted or used for other municipal purposes or operation.

2. No obligation rests upon any municipality to furnish water free of charge to public school buildings or other public buildings.

The Cleveland Appellate District (which includes the city of Cleveland) seems, however, to be exempt from the ruling of the Supreme Court in this case. This is due to the fact that a previous case (identical in every detail with the Columbus case) was carried through the Cleveland Court of Appeals to the Supreme Court in which the lower court declared the law constitutional. To overrule any Court of Appeals on a constitutional question requires the concurrence of at least all but one of the judges of the Supreme Court. In the Cleveland case the Supreme Court held the law constitutional by a vote of 2 to 5 while in the Columbus case the same law which was held unconstitutional by the Columbus Court of Appeals was held unconstitutional also by the Supreme Court by a vote of 5 to 2. We believe that municipalities may charge for water, therefore, furnished to public schools and other public buildings in all parts of Ohio except in the Cleveland Court of Appeals District and possibly in the 9th District. Because of the constitutional provision referred to above the Ohio chief justice says "It would be difficult to describe or even imagine a more deplorable situation." A new taxpayers suit has already been started to meet this peculiar situation in Cleveland.

3. By virtue of the Camp Wise case no municipality is obliged to furnish free water to a charitable institution.

4. With reference to cemeteries, whether municipal or private, and also public libraries, there is not now, nor has there ever been, any authority in the law of Ohio permitting or requiring a municipally owned water works to furnish free water to them.

5. No obligation rests upon any municipality by virtue of any law of the State of Ohio to furnish free water for extinguishing fires, cleaning fire apparatus or for furnishing or supplying connections with fire hydrants or keeping them in repair for fire department purposes. (Sec. 14769 G. C. was declared unconstitutional in the Camp Wise case.)

Public Utility Commissions Decisions.—We find the Public Utility Commissions generally inclined to rule against free municipal service or special rates as unjustly discriminatory. A much more extended investigation of the commission acts and ruling is necessary, however, as a basis for a complete and final report.

We find two Indiana cases (P.U.R. 1919 F. 38, 1919, and P.U.R. 1921 A. 1921) which hold that a charge by a municipal utility to churches and charitable institutions of a rate less than that charged other consumers for the same service was discriminatory. The Missouri Commission (1917 Mo.) P.U.R. 1917 D. 224, holds that the furnishing of free water from a municipal water plant to churches and schools in the city, while other consumers were charged for a like service constituted unlawful discrimination. Similar decisions have been reached by various commissions (including Montana, Maine, Connecticut and Wisconsin) with regard to the furnishing of water for fire protection purposes.

A summary of our position at this point is desirable. We find that 70 per cent of the water works in the United States are municipal; as a rule a municipal water works represents the city in its proprietary or private business capacity and as such it has the same freedom of action as a private utility corporation but is supposedly subject to the same restrictions as to practices of discrimination in rates and service; that both courts and commissions have rules both for and against free municipal water for various uses the controlling weight of the commission decisions being against the practice. These findings, however, are based only upon a preliminary study of the law. They do not represent conclusions resulting from long, careful and critical examination or legal research. To some degree, however, they show the trend of certain legal doctrines as to the use of water works funds for other than water works purposes. So much for the law.

Actual Practice.—There is ample evidence that the practice of spending the water customer's money for other purposes of government and also for furnishing free water and free service is one of long standing. It has been spoken of as a "left over" from the days of political patronage. In the records of this association

we find that since 1895, forty papers have been read at our conventions dealing directly or indirectly with free water and its abuses. We have all talked much about it.

In 1929 at the San Francisco convention in a paper on this subject we unfolded a brief story of the enormous diversion of water works funds as it applied to representative cities in more than a dozen states of the Union. We discussed at length the extravagant and wasteful free water policy then in force in Cleveland, O. It is still in force there due to the curious quirk in the Ohio constitution as explained elsewhere in this report.

We believe there has been little if any change in this policy throughout the country since our last report. We are certain that contrary to existing laws, court decisions and commission rulings, "discrimination" is being practiced by municipal water works in the making of rates and granting of free service; that water works funds sadly needed for expansion to meet growing community needs and demands for pure water, are being diverted for other purposes and that such practices in some states are seriously entangled with proposals to increase water rates.

Acknowledgment.—The foregoing is an abstract of a paper presented May 26 at the 51st annual convention of the American Water Works Association.

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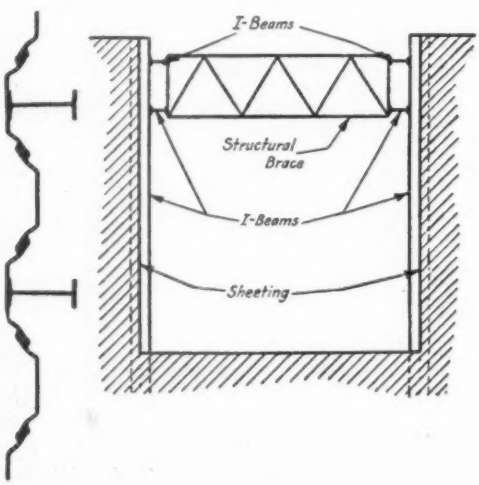
Sewer Junction Chamber Constructed by Unusual Method

The major portion of Section 5 of the Olentangy intercepting sewer for the city of Columbus, Ohio, consists of tunnel work. One portion of the work done in a rather interesting manner was the excavation of a junction chamber 172 ft. long, 41 ft. wide and 34 ft. deep. The coffer for this chamber consisted of Jones & Laughlin arch-web sheeting in 37-ft. lengths, driven with a 12-in. 31.8-lb. I-beam riveted to every other sheet.

The contractor cut a trench 18 ft. deep with a trench-hoe. The steel was then set up in the trench and driven the rest of the 37-ft. distance with a Link-Belt crawler gas crane with a 60-ft. boom and a McKiernan-Terry steam hammer. Excavation with the hoe continued, trucks being pulled out on a dirt ramp dug by the crane with a clamshell bucket. When the hoe had dug to a depth of 20 ft., steel trusses were set by the crane across the top of the 41-ft.-wide trench to brace the sheeting. The excavation down to the required depth was then completed by the trench-hoe.



Method of Bracing Sheeting

Driving the Steel Sheeting

By proceeding in this fashion there was no bracing in the way of the excavating machinery, and the 4,000 cu. yd. of concrete work involved in the chamber was enabled to proceed without hindrance. Altogether, 90 per cent of the dirt was excavated by the hoe and the remainder, consisting of the ramp, was removed with the clamshell bucket. The contract for Section 5, amounting to approximately $500,000, is held by Walter S. Rae.

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Taste and Odor Removal at Maryland Plants

The following note is taken from an advance copy of the 1930 report of the Bureau of Sanitary Engineering of the Maryland State Department of Health, of which Abel Wolman, is chief engineer:

During the year several of the larger water treatment plants of the state have been more or less successful in combating the usual seasonal tastes and odors peculiar to surface water supplies. In the Washington Suburban Sanitary District the Hyattsville and Burnt Mills supplies have been treated with partial success by the application of ammonia in the mixing chamber before coagulation and chlorination after filtration. The interval between ammonia and chlorine applications was one hour. Experimental work is being conducted at these plants to determine the relative efficiencies of various points of application of both ammonia and chlorine.

At Hagerstown success has been obtained by the similar application of ammonia and chlorine after filtration. At Baltimore prechlorination with ammonia added at the same point in the mixing basin was successful. The detention before filtration was about 40 minutes. A residual of 0.1 per million chlorine was maintained after filtration, thus requiring no post chlorination. The Bureau of Sanitary Engineering has suggested experiments with dry feeding activated charcoal prior to coagulation. This work will likely be conducted during the coming year at these plants.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by A. ELLIOTT KIMBERLY, Associate Editor
Consulting Sanitary Engineer, Columbus, O.

Prechlorination at Dayton, O., Sewage Works

PRECHLORINATION of sewage for odor control will shortly be included in the treatment program of the sewage of Dayton, O. While larger installations have been made for disinfection, it is believed that the Dayton installation is among the largest using chlorine for the prevention of odors arising from escaping hydrogen sulphide and allied gases.

The situation at Dayton is somewhat unusual. The site of the sewage works is a tract of 500 acres, situated on the west bank of the Miami River about 3.5 miles below the center of the city. A site of this size was purchased particularly with a view to isolation and the prevention of odors. The plant is effectively landscaped and an 18-hole golf course adjoins the sewage works. Operating experiences during the very dry summer and fall of 1930, however, show that stale sewage containing considerable hydrogen sulphide and emitting objectionable odors must be anticipated. Prechlorination was therefore adopted with a view to odor reduction, especially because of the adjoining golf course and the other recreational features which city parks afford.

Preliminary to a description of the Dayton installation, comments appear of timely interest on the salient features of the general application of chlorine to odor control problems in sewage work as reflected by current experiences. Chlorine has, of course, long been recognized and used as a valuable and indispensable adjunct to water purification, and in recent years, particularly through the efforts of the Chlorine Institute of New York, there is an increasing appreciation of its great value in sewage treatment from the standpoints of disinfection, odor control and BOD reduction.

Generally speaking, sewage treatment practice appears able to cope with the unsightliness of sewage, but fails in many instances to provide the odorless operation which a critical public demands. Chlorine gas is an effective and cheap agent for the control of sewage odors and its use for this purpose appears to be steadily increasing.

Sewage Chlorination in Germany.—Current technical literature contains many references to the successful application of chlorine for the control of sewage odors. A very comprehensive article on sewage chlorination was written in 1925 by Dr. H. Bach,[1] Chief Chemist, Emscher Corporation, Essen, Germany. This paper, although specifically indicative of German practice, most instructively covers the application of chlorine in sewage work and in substantially all respects, appears of general applicability.

It is pointed out by Dr. Bach that the bacterial treatment of sewage removes its capacity for decaying, but cannot eliminate odors at the treatment works, if the sewage is already putrescent. Furthermore, methods of distributing sewage on filters often increase the odors at the plant and in fact, in sewage work the anaerobic decomposition of submerged sewage sludge is the only process non-productive of odors.

Still another often important function of sewage treatment is the destruction of pathogenic bacteria. Chlorine provides the required disinfection and is admirably adapted to control odors.

Relative to odor control, Dr. Bach stresses the fact that sewage is not particularly offensive to smell until hydrogen sulphide is developed by the decomposition by the organic, albuminous and sulphur compounds. He makes the important comment that the odor of decomposed sewage can be prevented from escaping into the air, only by destroying, in part at least, the dissolved hydrogen sulphide, which even when present in very low concentrations, seriously contaminates the air.

Chlorine gas removes the objectionable hydrogen sulphide with the separation of sulphur and the formation of hydrochloric acid. The reaction takes precedence over reactions of chlorine with other substances in the sewage. The quantity of chlorine required corresponds to the sulphur present in the form of hydrogen sulphide or readily hydrolyzable sulphides. Approximately two parts of chlorine are required for each part of hydrogen sulphide.

It is further mentioned by Dr. Bach that the objectionable odor of stale sewage is due not to the entire hydrogen sulphide content, but only to that fractional part which escapes into the air as a gas. It is therefore not necessary to eliminate all the hydrogen sulphide in the sewage, but merely to reduce the total quantity present.

Because of the instantaneous action of chlorine on hydrogen sulphide, it is unnecessary to provide a definite period of retention. Thorough mixing is alone essential.

Chlorine has been used at a number of clarification plants in Germany, strictly for odor control. The chlorine dosage ranges from 4 to 8 ppm.

Sewage Chlorination in America.—Turning to American literature, Enslow[2] states that in America and in England, upwards of twenty cities (1929) have adopted prechlorination to abate odor nuisances. The discussion of the paper brings out experiences with prechlorination for odor control at Miami, Ariz., since 1923. Enslow's paper refers also to prechlorination at Virginia Beach, Va., whereby odors from the effluents from septic tanks are substantially reduced. At this plant, the dosage ranges from 10 ppm. in cool weather to 20 ppm. during the summer months.

In still another paper, Enslow[3] points out that odor control by prechlorination is established practice at

Schenectady, N. Y.; Plainfield, N. J.; Independence and Neodsha, Kans.; San Bernardino and New Port Beach, Calif.; Haddonfield and Totowa, N. J.; Las Cruces, N. M.; Kerrville, Tex., and Bath, England.

At two plants in California, chlorine is successfully used to control odors arising from the treatment of milk wastes by broad irrigation.

Studies at Plainfield, N. J., are discussed by William J. O'Connell, Jr.,[4] who summarizes his experiences with the use of chlorine as follows:

"1. Odor control is the result of the bacterial reduction by chlorine and of the direct reaction with H_2S.

"2. H_2S is the measure of potential odor production.

"3. Prechlorination is found to be the most effective practice.

"4. The time and amount of dosage is dependent upon local conditions.

"5. At Plainfield, complete control is accomplished during the warmer months of the year by application of 66 lb. of chlorine between 4:30 and 8:30 P. M."

The 66 lb. used per day at Plainfield corresponds to a dosage of 12 ppm. Under Plainfield conditions, four hour treatment has been found to be sufficient to effect satisfactory odor control.

Still another New Jersey experience is described by Sparmaker and Forman.[5] The raw sewage was prechlorinated, first at the rate of 10 ppm., based on the average daily flow. This rate of treatment effected a 30 per cent reduction in the hydrogen sulphide content. At a rate of 14.5 ppm., the hydrogen sulphide reduction was about 75 per cent. It was further found necessary to use as much as 20 ppm. of applied chlorine, to obtain residual chlorine continuously in the tank effluent. These Haddenfield experiences indicated the necessity for maintaining residual chlorine in the Imhoff tank effluent to prevent hydrogen sulphide odors.

In this connection, later researches have shown that residual chlorine in the settling tank effluent may interfere with sludge digestion. In fact, the interim report[6] of the Sanitary Engineering Division Committee of the American Society of Civil Engineers on programs at New Jersey Experiment Station, states with reference to the chlorination of raw sewage: "Liquid chlorine may be added to raw sewage for the purpose of killing slimes and preventing the development of foul odors, without inhibiting sludge digestion, providing the chlorine is not added in sufficient quantity to produce 'residual chlorine' in the sewage leaving the settling basins."

Chlorine is also useful to prevent the disintegration of cement and concrete. This feature is strikingly evidenced by experiences at the Los Angeles, Orange County and El Centro, Calif., sewer outfalls. As described by R. F. Goudey,[7] chlorine was primarily applied to control odors at the outfalls.

The three Orange County outfalls receive the sewage from a population of about 70,000, and are linked together by an outfall sewer system, varying in size from 18 to 42 in. in diameter. The length of the trunk sewer is about 26 miles. The sewage flow is about 5.0 mgd. The sewage is high in mineral sulphates and as a result of the action of sulphur splitting bacteria, the hydrogen sulphide content ranges from 3.0 to as high as 24 ppm. for one of the sewers, averaging perhaps 4 ppm. By the use of chlorine, the hydrogen sulphide is reduced to 1 ppm. and below, the odor is effectively controlled and the reduction of mineral sulphates is prevented.

At the Orange County installations, chlorine costs $1.75 per million gallons. It decreases the oxygen demand and also prevents the disintegration of the sewer jointing material. The paper concludes with the statement that "by chlorinating at a cost of $3,000 a year, the outfall sewer investment of nearly $1,000,000 can be saved."

These experiences indicate that the chlorination of stale sewage, especially if high in sulphates, should receive careful consideration not alone from the standpoint of odor control, but also, with respect to the continued integrity of the concrete structures at the sewage plant.

The above brief excerpts from current literature indicate that prechlorination is an established practical program for odor control at many plants. The new Dayton installation represents merely an addition to the relatively large number of sewage plants where chlorine has already satisfactorily and economically solved the stale sewage odor problem.

Sewage Treatment and Prechlorination at Dayton.—The Dayton, O., sewage treatment works began official operations on Nov. 21, 1929. Preparatory treatment only is provided, deemed sufficient until 1935 at least. As of that year, the capacity of the plant is sufficient for a population of 262,000, with an estimated sewage flow of 26.0 mgd. The plant includes skimming tanks, grit channels, Imhoff tanks, sludge digestion and special provisions for sludge drying.

The contract cost of the sewage works proper, exclusive of pumping arrangements and force mains was about $830,000; that of the complete project, approximately $1,714,000. The plant was designed by Metcalf and Eddy of Boston.

Sewage Treatment Works.—With the exception of one district comprising about one-quarter the total area of the city, Dayton is sewered on the separate plan. Considerable increase in flow occurs during wet weather.

The sewage flows by gravity into a pumping station, where after passing through 4-in. bar racks, it is pumped to the treatment works through a 5,385-ft. long, 54-in. precast concrete force main, with leadite joints.

The sewage first enters two 40-ft. diameter Dorr clarifiers, equipped with skimmers for the removal of grease and oil. The clarifiers are in continuous operation and the grit thereby forced to the center, is pumped to the grit channels. Here Link Belt flight conveyors drag the grit to the hoppers for ultimate disposal by dumping.

The sewage is next screened by fine Dorr screens 4 ft. by 6 ft., with ⅛ by 2-in. slots. The screenings are picked up by bucket elevators, which discharge into screenings presses, and are ultimately consumed in an incinerator.

The screened sewage is next settled in six Imhoff tanks, each 88 ft. 0 in. by 73 ft. 9 in., inside dimensions, arranged in two batteries of three tanks each. The tanks have an effective depth of 28.5 ft. and provide flowing through and sludge digestion capacities of 1.24 and 1.53 cu. ft. per capita, respectively.

Sludge flows through quick opening valves to sludge wells, from which ejectors force it to glass covered sludge beds. The Dayton plant includes 2.5 acres of sludge beds, comprising 11 units each 59 ft. 10 in. by 162 ft. 6 in., inside dimensions. Dried sludge is shoveled into cars and is hauled to a dump by a Plymouth gasoline engine. The sludge bed area is 0.4 sq. ft. per capita.

The Imhoff tank gases are collected in c.i. domes. The tops of the domes are 18 in. above the average sewage level. Under 12 to 18 in. water pressure, the gas flows to a compressor whereby it is compressed to

50 lb. per sq in. The compressed gas is stored in two buried pressure tanks.

Chlorination Plant.—The prechlorination plant is at present under construction and it is expected that operations will start about the middle of July.

The plant comprises spur trackage for handling chlorine in tank cars, an unloading tower, chlorine evaporator, chlorine machines, dry feeding machine for lime, heating equipment, chemical solution pumps and special connections to the sewage force main.

Chlorine is delivered to the plant in tank cars of 15 tons capacity. A steel unloading tower provides arrangements for conducting the gas through a line of flanged pipe to the chlorine evaporator. The tower is also provided with suitable connections for handling chlorine shipped in 1-ton containers.

The chlorine enters first a Wallace and Tiernan evaporator which is heated by hot water from a boiler fired by Imhoff tank gas, under thermostatic control.

The gaseous chlorine is definitely and accurately controlled and measured by four Wallace and Tiernan vacuum type, solution feed chlorinators. Two of the machines have fixed capacities of 720 lb. per 24 hrs. each and two a variable capacity up to 360 lb. in 24 hrs. The chlorine equipment, lime feeding devices and solution pumps are housed in an attractive building 10 by 28 ft. in plan, inside dimensions.

The discharge from each chlorinator is tapped into a 6-in. c.i. pipe line, in which flows milk of lime. Hydrated lime is fed by a Gauntt dry feeding machine, provided with a solution box, at such a rate as will convert the added chlorine to calcium hypochlorite.

The chlorinated lime water flows by gravity into a hoppered suction box, whence it is pumped into the 54-in. force main through four lines of 2-in. rubber hose. All iron Worthington centrifugal pumps, each of 125 gpm. capacity, force the chemical solution into the raw sewage. Each of the four 2-in. chemical solution discharge lines enters the force main at an angle of 34 deg. to the sewage flow. The point of application is 400 ft. upstream from the skimming clarifiers. Nozzles of special chlorine resistant material are provided, operating through special valves and stuffing boxes, so designed that each nozzle may quickly be removed for cleaning.

The cost of the prechlorination equipment was about $15,000.

The superintendent of the Dayton Sewage Works, M. W. Tatlock, through whose courtesy this description of the plant was obtained, states that it is tentatively planned to apply chlorine in conjunction with lime, daily from 8:00 a. m. to 8 p. m. at the rate of about 10 ppm.

As a result of laboratory studies, preliminary estimates of cost with chlorine at 2.5 ct. per pound and lime at $10.00 per ton in plant storage, indicated a cost of $1.30 per MG for chlorine alone or $1.19 per MG when both lime and chlorine are applied. The use of lime in conjunction with chlorine thus effects a reduction of about 25 per cent in the quantity of chlorine required to satisfy the chlorine demand.

Details of these estimates are as follows:

"Maximum chlorine demand, 12.5 ppm.

"Maximum daily hours chlorinated, 12.0.

"Maximum days chlorination required, 150.

"Each MG sewage will require 52 lb. of chlorine per day (12 hrs.) to supply its demand. This same demand can be satisfied by 25 per cent less chlorine if it is added with lime, that is, as calcium hypochlorite, or 39 lb. of chlorine as hypochlorite will satisfy the chlorine demand of the sewage as well as 52 lb. of chlorine alone. To make this hypochlorite will require 43 lb. of lime, $Ca(OH)_2$."

The contract for chlorine in tank cars f.o.b. the Dayton Sewage Works was awarded to the Mathieson Alkali Works, Inc., at its bid of $2.115 per cwt.

Judging from small scale tests, the use of chlorine at Dayton will not only overcome the warm weather odor nuisance, but will also appreciably reduce the BOD of the settled sewage. In the opinion of the Dayton officials, prechlorination is expected to postpone the required construction of oxydizing devices which the limited dilution in the Miami River will ultimately demand.

Operating results at Dayton during the coming summer and fall months will doubtless furnish instructive data as to the practical aspects of chlorination, in odor control, at relatively large sewage works.

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Cost of Sewage Treatment at Worcester, Mass.

The cost of sewage treatment at Worcester, Mass., in 1930 is summarized as follows by John H. Brooks, Jr., Superintendent of Sewers, in his annual report for the year ending Nov. 30, 1930:

	Total	Per Million Gallons
Screen	$ 7,210.14	$1.13
Grit Chamber	967.33	0.15
Imhoff Tanks	11,010.92	1.73
Trickling Filters	8,098.46	1.27
Secondary Tanks	5,292.73	0.83
Sludge Disposal	17,997.87	2.83
Laboratory	6,338.68	0.99
Total	$56,916.13	$8.93
Real Estate (Credit)	$ 1,768.77	

Including all material and supplies, teaming and department transfers of labor, the department records show a total net expenditure of $56,916.13, representing a cost of $8.93 per million gallons of sewage treated by the plant. All sewage received at the plant passed through the grit chambers and was screened before treatment or bypassed to the final effluent channel.

The cost of $8.93 represents an increase per million gallons of almost $1.50 as compared with last year. The total cost of $56,916.13 was about $1,300 greater than in 1929. Both figures include the cost of two mechanically raked bar screens, the elimination of which would make the total net expenditure about $3,500 less than that of 1929. The cost per million gallons treated was increased due to the 1,100 million gallons less of sewage treated during 1930. The cost of maintenance and operation of the sewage treatment plant based only on pay roll charges at the plant was approximately $6.24 per million gallons of sewage treated by the plant. Compared with the 1929 cost on the basis of equal quantities of sewage treated, the 1930 cost represents an increase of $0.11 per million gallons.

Recent Developments in Sewage Disposal Field

High Lights from Papers and Addresses at 4th Annual Meeting, Central States Sewage Works Association, Held May 22 and 23, at Madison, Wis.

THE fourth and largest attended annual meeting of the Central States Sewage Works Association with a registration of eighty-five was called to order at Madison, Wisconsin, by President F. W. Mohlman, Chief Chemist of the Chicago Sanitary District, at 10 a. m., May 22nd. The addresses of welcome by the Honorable Henry A. Huber, Lieutenant Governor of Wisconsin, Mayor Schmedeman of the City of Madison and Prof. F. E. Turneaure of the University of Wisconsin were followed by a heavy program of technical and scientific papers of interest. The president, Dr. Mohlman, and the Program Committee received a vote of appreciation from the members for the excellence of the program and the manner in which the meeting was conducted.

At the banquet, addresses were made by Dr. C. A. Harper, Health Officer of the State of Wisconsin, and Mr. Adolph Kanneberg, Chairman of the Wisconsin State Commission on Water Pollution, after which talks illustrated by motion pictures showing progress in waste disposal and stream cleansing were made by L. F. Warrick, State Sanitary Engineer of Wisconsin, and G. H. Radebaugh, Manager Champaign-Urbana, Illinois, Sanitary District.

Some of the high-lights gathered from the talks made and papers read in the technical sessions follow:

Stream Pollution Abatement.—Harry F. Ferguson, Chief Engineer, State Department of Health of Illinois, recounted the progress made in stream pollution abatement in Illinois. Mr. Ferguson is also the technical secretary of the Sanitary Water Board created by legislative act of 1929 which has, during its 18 months of functioning, surveyed 108 streams covering 600 or more miles of water-way. In one particular instance a plant producing strawboard created by its waste discharge a pollution problem extending 30 miles down stream. The most important stream study made is that covering the Fox River.

Beautification of Sewage Works.—W. A. Sperry, Superintendent Aurora, Illinois, Sanitary District, made an appeal for sewage works beautification and outlined measures employed at the Aurora plant for the purpose of interesting and educating the public in the matter of sewage works operation and maintenance. It was an excellent presentation full of practical suggestions put into effect at the Aurora plant. In particular, the use of framed statements appropriately placed and descriptive of the several parts of the plant and their particular function and the wearing of sanitary appearing suits by the operators are appealing. In discussion G. H. Radebaugh related the success of the endeavors of the Champaign-Urbana authorities in attracting the attention of the public and securing good-will. Mr. Radebaugh stressed the value of flower beds at the sewage works and believes that flowers are "cheaper than weeds anytime." He recommends the impressiveness of showing visitors fish living in the sewage plant effluent as indication of how effective the purification has been. Mr. Ferguson spoke of the efforts at the Springfield, Illinois, works to attract and educate the public in sewage treatment and also paid a handsome compliment to Mr. Radebaugh for his successful pioneering in the "clean-stream movement" throughout the State.

Protozoan Life and Bacterial Destruction.—At the afternoon session a highly instructive lecture on the relationship of protozoan life to bacterial destruction or

Those Present at the Fourth Annual Meeting of the Central States Sewage Works Association, Madison, Wis., May 22-23

Bottom Row, Left to Right: John C. Mackin, L. H. Enslow, H. O. Halvorson, Gus H. Radebaugh, Harry F. Ferguson, Howard W. Harman, Louis F. Warrick, Glenn Frank, President University of Wisconsin, F. W. Mohlman, L. S. Finch, H. E. Wilson, E. E. Smith, G. P. Edwards, C. C. Larson, Mr. Nelson.

Second Row, Left to Right: J. A. Childs, G. R. Barnett, O. E. Schwartz, C. C. Ruchhoft, H. E. Schlenz, C. N. Ward, Ed. Ward, W. A. Peirce, Mr. Porter, S. Grant, R. T. Steindorf, R. E. Beaudoin, E. Hurwitz, W. W. Fry.

Third Row, Left to Right: Harry Karl, Frank Woodbury Jones, Chas. Brossman, Leon G. Williams, J. Donald Walker, W. H. Wisely, B. Domogalla, Christ Deckert, O. M. Leonard, Edwin C. Hurd, W. D. Hatfield, H. W. Ruf, E. Baillie, G. H. Van Dyke, Gladys Swope, Frank Bachmann.

Fourth Row, Left to Right: Wm. Phillips, Arthur L. Boley, O. Knechtges, F. R. King, Mr. Shaw, H. G. Rogers, W. J. Downer, C. E. Schwob, E. C. McComb, E. F. Eldridge, W. L. Mallmann, Max Suter, H. S. Merz, Mr. Galligan, H. Hersig, Geo. Martin.

Top Row, Left to Right: M. Starr Nichols, Ray Offensmann, P. J. Cerny, E. H. Parks, H. H. Young, Wayne Kivell, Not Known, J. M. Holderby, E. J. Beatty, Walter A. Sperry, Mr. Rice, Russell S. Smith, J. K. Giesey, C. R. Velzy, A. M. Buswell, Max Levine, E. J. Theriault, W. B. Walraven, B. Hartman, F. M. Dawson.

multiplication was given by L. E. Noland, in which it was stated that the ciliates as a class are very active eaters of bacteria—actually digesting them. One Paramaecium, for instance, will digest (destroy) 60,000 bacteria every ten hours. It is very exceptional that protozoa can or do live in absence of a bacterial food supply. Protozoa digest protein and some few also digest fats and starch. There are known forms of anaerobic protozoa (metopus et al.) in addition to many facultative forms. The flagellates are the earliest protozoa to appear in sewage because they require but little oxygen. Temperature changes do not have any pronounced effect on protozoan metabolism, but they cannot stand much if any higher temperature than 32° centigrade.

Biology of Activated Sludge.—Dr. A. M. Buswell, Chief, Illinois State Water Survey, presented a review covering the activated sludge process in which the fact was stressed that there are two distinctive stages in the biology of the process. The first is the "bio-precipitation" stage in which dispersed organic material is coagulated or clotted into flocs and the succeeding stage is that of oxidation and nitrification or "wet-burning" of organic matters in the sewage. Of the protozoan forms in activated-sludge opecularia predominate. The same is also found to be true in the film on sprinkling filter bed stone. In activated sludge the commonly-observed vorticella appear only after prolonged aeration. The volume of air forced through the sewage has a definite influence on the types of protozoa found. The presence of sphaerotilus, which is a sewage fungus, is indicative of deficient aeration of activated sludge and causes "bulking" of sludges—especially when glucose, maltose, lactose and other sugars appear in the sewage.

Significance of Micro-Organisms in Sewage Treatment.—Robert Cramer, Consulting Engineer, Milwaukee, Wisconsin, recounted the results of small scale experiments conducted by himself from which conclusions were drawn that protozoa in essentially pure culture produced satisfactory results in the activated sludge process. In certain experiments a solution of potassium chlorate was employed as the source of oxygen rather than air and with results very similar to those secured from aeration. Following best sterilization at 60° centigrade to destroy the protozoa but not bacterial life, there was little or no production of activated sludge and purification was of low efficiency even with prolonged aeration. Seeding such a sample with one or two protozoa (Paramecium) resulted in the building up of an effective sludge and efficient purification. In discussion, Dr. Max Levine and Mr. Ruchroft questioned the value of the experiments in view of the ease with which practically all of the bacteria are destroyed in activated sludge by holding for 15 minutes at 60° centigrade. There was also some question concerning the effect of heat on the colloids in sewage. Dr. Mohlman called attention to the recent work of Dr. Ardern in England which indicates that large numbers of protozoa in activated sludges are only incidental to the end results and not a criterion. Mr. Cramer replied that his experiments were acknowledgedly limited in scope and the many variables may have caused some confusion in the interpretations.

Control of the Sewage Filter Fly.—Dr. Max Levine reported on results of an investigation conducted by Mr. W. W. Frye under his direction which dealt with measures for controlling the sewage filter-fly (Psychoda Alternata). Studies disclosed that increasing concentration of chlorine in aqueous solutions destroyed increasing numbers of the submerged larvae of the filter fly. The more effective result in practice, however, would seem to be secured by the sloughing off of the heavy surface film from the stone carrying with it the larvae when there are actual destruction of living larvae. In addition to chlorine many insecticides were tried, including Nicotine Sulphate, Borax, etc., with about equal results. In view of the fact that the filter was housed-in, methods of destroying the adult fly rather than the larvae seemed feasible. Spraying the walls and ceilings with kerosene oil containing ¼ lb. of Pyretheum powder to the gallon proved highly satisfactory and not too expensive to be practical. One thorough spraying each 10 days to two weeks seems to keep the fly population under satisfactory control at two sewage plants.

Pre-Aeration of Settled Sewage at Decatur, Illinois.—Dr. W. D. Hatfield reported on the operation of the pre-aeration plant at Decatur, Illinois. This plant aerates or partially activates Imhoff tank effluent prior to application to sprinkling filters and has proven a satisfactory scheme for reducing the oxygen demand of the settled sewage containing a corn products plant waste by approximately 30 per cent and thus allows heavier volume loading on the filters. It is possible thereby to treat the entire sewage flow on the filter which otherwise could not be done. With 2.5 hours diffused air aeration of the settled sewage some sludge is built up which consists largely of zoogleal masses containing few if any protozoa. With 0.3 cu. ft. air per gallon the effluent leaving the clarifiers between the aeration tanks and the filters will have 30 per cent less 5 day bio-chemical oxygen demand (B.O.D.) than the settled sewage. Increased air to 0.4 cu. ft. per gallon gives a 40 per cent reduction. Schemes employing return of sludge (10 per cent) to the aeration tanks improve the efficiency of the aeration but slightly. Sludge reaeration is not practical because of limited air capacity which results in septization of the sludge with attendant odor production. The overall B.O.D. reduction through the entire plant is normally 90 to 95 per cent, the Imhoff tanks being responsible for but 22 per cent and the filter 40 to 45 per cent, leaving 25 to 30 per cent accounted for by the 2.5 hours aeration (0.3 cu. ft. air per gallon) preceding the filters. On the whole, the most practical aeration is without return of sludge, much of which passes through the clarifiers onto the filters but fortunately without detrimental effects on these rugged units.

Experience with Submerged Paddle Agitators for Activated Sludge.—W. A. Kivell of the Dorr Company brought up-to-date experiences with activated sludge treatment, wherein submerged paddle agitators circulate the sludge and produce better air distribution, thus reducing air consumption which in turn represents reduced power consumption and operating costs of the activated sludge process. Among the conclusions were the following: The air consumption can be reduced from 0.8 cu. ft. to 0.2 cu. ft. per gallon. Four to five hours aeration period is adequate. Power consumption predicted is 14 to 15 HP. per million gallons as compared with 26 HP. ordinarily required when diffused air is the sole means of aeration and mixing.

Experiments on Thermophilic Digestion.—Dr. F. W. Mohlman presented a joint paper by himself and G. P. Edwards reporting on preliminary experiments on thermophilic digestion of sewage solids. Material employed was an equal mixture by weight (dry basis) of fresh solids with activated sludge. For seeding 50 per cent of digested or partially digested sludge was employed. Of the digesting temperatures employed, 68, 86, 100 and 122°F, the higher temperature eventually produced

the most rapid digestion without the lag initially noted. This, however, did not prevail until several re-inoculations were employed which apparently resulted in the building up of the thermophilic culture and gradual elimination of extraneous organisms. Fresh solids and activated sluge could be added to the high temperature (122°F) digestion flasks up to 8 per cent daily without difficulty whereas 10 per cent additions overcrowded the digestion. Solids sterilized prior to use digested more promptly than otherwise and this observation points to the apparent necessity of reducing the flora and fauna to specific species before best results with thermophilic digestion can be secured. After the second re-inoculation at 122°F. digestion was for all practical intent completed after a 15-day period. Certain undesirable features of the high-temperature digestion were stressed. The odors produced are very objectionable and tense. The supernatant liquor is extremely high in ammonia compounds and suspended and dissolved solids—4,000 parts per million suspended solids being noted at times. The thermophilic process appears to be rather delicate and requires more perfect control than ordinary digestion. Serious odor production and the inferior supernatant liquor appear to be the features which will defer progress with high temperature digestion unless some means can be developed to reduce these difficulties.

In discussion C. C. Ruchroft brought out the point that a study of organisms thriving in the 122°F cultures were composed of 5 species of thermophilic organisms plus certain thermotolerant forms. The actual counts indicated 90 to 100 million of the high temperature organisms per cubic centimeter of sludge as compared to one million per c.c. observed at ordinary temperatures. The seriousness of odors and the inferior quality of supernatant liquid was stressed by G. P. Edwards, co-author of the paper. The large scale results from parallel operations at the Aurora, Illinois, Sewage Works comparing 90° and 130°F digestion were reported upon by Frank Bachman. The program was run on an 8 per cent colids addition—i.e. 12.5 day theoretical digestion period in each case. The experiences were practically identical with those reported from the Chicago studies. Moreover the sludge drawn from the high temperature tank was extremely difficult to dewater on sand beds. The high concentration of suspended solids would not settle out from the so-called supernatant liquor displaced from the digestors. The conclusion reached to date from the Aurora results is that thermophilic digestion is not worth the additional operating cost involved and at this stage is far from being a practical process.

Further in Discussion.—Dr. Max Levine recounted his experience with 350 gal. experimental tanks digesting solids at high temperatures wherein 7 per cent of fresh solids from packing plant waste was added daily. Gas production was 85 per cent complete within 9 days of digestion and the gas contained a higher hydrogen content than is normally found. The odor and sludge dewatering difficulties rendered the process non-practical. W. A. Sperry of Aurora stressed the point that the gas produced at high temperature sludge digestion was objectionable also because of its greater hydrogen sulphide content than appears during 85°F. digestion. Hydrogen sulphide is very destructive when burned under heating boilers.

Dr. Bernard Domogalla reported on extensive studies conducted to determine the cause of heavy aquatic growths in the lakes around Madison and the most feasible measures for their eradication.

Sewage Disposal Problems of Minneapolis and St. Paul.—J. A. Childs, Chief Engineer, Minneapolis-St. Paul Metropolitan Drainage Commission, gave an up to the minute review of progress made in river studies to indicate the present conditions of the Mississippi River above and below the Twin Cities and South St. Paul area. The recommended scheme for collection and treatment of the combined domestic sewage and trade wastes representing a total dry weather flow of 100 million gallons per day and population equivalent of 1,300,000 persons was outlined. The contribution of waste from the meat packing industry in South St. Paul represents 25 per cent of the total stream pollution from the area under study. To treat the packing plant waste with the domestic sewage an estimated additional $150,000 per year operating cost will be required. It is estimated that these wastes treated separately at South St. Paul by the packers could be done more economically than otherwise. The city of St. Paul until recently has insisted that the South St. Paul sewage and wastes be handled in a jointly operated works serving Minneapolis and St. Paul. A bill passed by the 1930 Minnesota Legislature called for proration of plant cost and operation charges on an assessment basis which did not take into account the difficult nature of meat packers' wastes and the high additional operation costs which would be thus placed on the joint works. The bill was protested by Minneapolis and vetoed by Governor Olsen in view of the evidence existing that packing wastes may be properly treated by one or more recently perfected processes at reasonable expense if not some profit return on the material recovered from the wastes. On June 8th the citizens of Minneapolis will vote on a charter amendment which will allow the city to finance and proceed with sewage disposal plans independently should St. Paul refuse to enter into the project on a pro-rata basis. In the meantime the authorities of the Twin Cities are considering possible arrangements for a jointly owned plant. For the present South St. Paul has announced that it will withdraw from the plan—assumedly with the intent of treating its wastes independently provided that the cities of Minneapolis and St. Paul can reach an agreement.

Purification of Packing House Wastes at the Hormel Plant.—Dr. H. O. Halvorson delivered an illustrated talk on the recently developed process used in purifying packing plant wastes wherein valuable protein bodies and fats are precipitated and recovered. Precipitation results from super-chlorination of the settled wastes. The process has now been in operation at the Austin, Minnesota, plant of Geo. A. Hormel & Co. for several months. This plant having a kill of 5,000 hogs per day approximately, recovers dry protein bearing material in amounts up to 5 tons per day containing, roughly, 8 per cent available nitrogen. The wastes seem to be most effectively treated in highly concentrated and the freshest possible condition. About three tons of solids per day are removed in a Dorr clarifier without chemical treatment. To the primary effluent chlorine is added and the precipitated material removed in the second clarifier amounts to roughly 2 tons per day. The two sludges are mixed, filtered on vacuum filters and dried. The high grease content of the sludge precipitated with chlorine will probably make degreasing necessary in which case, roughly, one ton of fat per day will be recovered. It is possible to precipitate 90 per cent of the organic nitrogen content of the wastes if they are fresh. Stale wastes yield as low as 60 per cent nitrogen recovery. In plant practice the average has been 73 per cent recovery of organic nitrogen and 98 per cent removal of suspended solids. The biochemical oxygen demand reduction is reported to be

roughly 85 per cent but by existing laboratory methods cannot be accurately determined. The present total costs of treatment at the Hormel plant including depreciation amounts to approximately $22,000 per year, which can be reduced decidedly when equipment is installed for more accurately apportioning the chlorine application to meet variations in flows. Returns from the sale of dried sludge will pay the operating costs and yield a profit provided the material is sold as stock food rather than as a fertilizer base. The chlorine is applied in quantity to insure a residual chlorine value of 50 parts per million in the precipitation tanks and represents a ratio of 1.5 lb. of chlorine per pound of total nitrogen present in the effluent from the plain settling tank. A pH of 4 or thereabouts appears to be the optimum condition for the precipitation and maximum nitrogen recovery. The final effluent is discharged direct to the river at Austin and has very materially improved conditions even to the extent that the stream is now non-odorous, is sightly and supports fish life a short distance below the sewer outlet as contrasted with the odorous and foul conditions existing prior to the present year.

In discussion, Dr. A. M. Buswell criticized the process as being less efficient than the biological processes to which Dr. Halvorson's reply was a comparative statement on costs of the two processes, the nuisance production from biological plants, area required and vagaries of the known biological processes. He really believed that the effluent from the chlorination-precipitation tank should preferably be disposed of through municipally owned sewerage systems thus benefiting from the available chlorine contained therein rather than direct discharge to water courses unless the municipal sewers are not available.

Ideal Small Sewage Treatment Works.—Chas. Brossman of Indianapolis in an illustrated talk described an ideal small sewage treatment works in which a housed-in settling tank and sprinkling filter equipped with a uniquely designed distributor of the rotary type is employed. The plant is very closely located to buildings and residences and has operated satisfactorily without filter fly or odor nuisance. The economy of operation and constancy of performance efficiency with a minimum amount of attention indicate the practicability of this type of treatment works for small or medium sized installations.

Disposal of "Humus" Sludge from Final Settling Tanks.—H. E. Wilson reported on experiences with digestion "humus" sludge from final settling tanks. Return of this material to Imhoff tanks created foaming and solids rising into the flow chambers through the slots. Experience indicates that the most satisfactory scheme is digestion of "humus" in separate tanks, using lime to maintain a relatively high pH value. In discussion F. W. Jones of Cleveland, O., warned against "humus" return to the crude sewage entering Imhoff tanks. Return to the digestion compartment also gives rise to trouble and very inferior effluent unless added very gradually—preferably at a continuous but moderate rate. W. D. Hatfield returns humus to crude sewage using pumps which are operated 4 times daily. Frank Bachman advocated return continuously to crude sewage by operating slow velocity sludge pumps. G. H. Radebaugh had tried returning "humus" sludge to crude sewage entering Imhoff tanks and experienced difficulties with tank operation. Return during night flow improved conditions somewhat but the procedure is still unsatisfactory and the problem needs study. Sprays in gas vents of the Imhoff tanks did not afford relief from such difficulties, whereas the more practical scheme of hydraulically removing scum to sand beds for drying and disposal had proven a satisfactory and labor saving scheme. L. H. Enslow reported on experiences of a similar nature and found removal of scum containing oil, hair and other indigestible materials by gravity arrangement to sand-beds had been a practical solution to the problem. The scum dewaters and dries more rapidly than sludge. Removed from the beds it can be piled and burned easily because of its low mineral content and highly combustible nature or it may be incinerated or discarded on the sludge dump as preferred. It should not be used on the land for fertilizer because of its objectionable nature and particularly its oil and grease content.

Studies Covering the B.O.D. Determination.—Dr. F. W. Mohlman reported on further studies of the biochemical oxygen demand (B.O.D.) determination. The use of dilution water consisting of distilled water containing 300 parts per million of bicarbonate of soda continues to give the most dependable results. A pH value of the diluted samples within the range of 6.5 to 7.8 prior to incubation is satisfactory. The use of dilution water containing 42.5 parts per million of potassium acid phosphate KH_2P04 adjusted with caustic soda to a pH of 7.8 as recommended by Theriault of the U. S. Public Health Service Laboratories, has been studied in the Chicago Sanitary District Laboratories by E. Hurwitz and G. R. Barnett. The conclusion reached is that the sodium bicarbonate water (300 p.p.m. $NaHC0_3$) is just as satisfactory and from a practical point of view is preferable to the phosphate water adjusted for pH value.

New Officials Elected.—New officers elected for the ensuing year follow:

President—L. F. Warrick.
1st Vice President—C. K. Calvert.
2nd Vice President—H. F. Ferguson.
Secretary-Treasurer—L. H. Radebaugh.

Resolutions passed included one lamenting the death of a member, John Macklin, former Superintendent of Sewage Works at Madison, Wisconsin—a pioneer in sewage treatment, an inspiration to younger operators, and a tireless worker in behalf of the Association. Let there be more John Macklins!

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METERAGE IN BRISBANE, AUSTRALIA.—The average daily per capita consumption of Brisbane, Australia, for 1930 was 39.93 Imp. Gal., according to the annual report of the Water Supply and Sewerage Department of which W. E. Bush is Chief Engineer. The consumption for previous years was 1926, 52.46 Imp. Gal.; 1927, 43.68 Imp. Gal.; 1928, 43.85 Imp. Gal.; 1929, 43.75 Imp. Gal. The report accounts for the decrease as follows:

"The diminution in consumption per capita per diem points to the fact that the increase in the metering of premises is having an appreciable effect on the consumption of water, and this is borne out by the fact that, in numerous cases where charges for excess have been made, the receipt of the first account has resulted in such care being exercised subsequently in the use of water as to eliminate excess consumption."

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WATER SUPPLIES IN VIRGINIA.—In 1900 only 20.3 per cent of the population of Virginia was served by public water supplies. In 1930 nearly 40 per cent were so served. In 1900, 81.8 per cent of the people served by public water works used water from untreated supplies; in 1930 only 8.8 per cent received untreated water.

. . . EDITORIALS . . .

The Crying Need of More "Intelligent Ignorance"

Trying to rate the mental powers of different men is like trying to determine which is the most important organ—the lungs, the liver or the heart. Yet a certain type of mind delights in selecting "the ten greatest living scientists" or "the seven greatest men of history." After recently making such an attempt, a scientific writer says: "Probably there will be those to say that ignorance is deplorably evident in my selections. Maybe so. It would take a truly great man to select the world's greatest, and a great man would have too much sense to try." Let us hope so, but let us be not too hopeful. Even great men are prone to believe that they can weigh the mental capacities of their contemporaries, as witness many a biography that tells of such attempts.

Just after some authority has predicted that the next great discovery will be made by one of a certain few great scientists, behold it is made by an entirely unknown man, often by a person with but little previous experience in the field to which his discovery relates.

C. F. Kettering, head of the General Motors Research Corporation, recently said: "When we want a man to work on a (research) problem we ask him if he knows anything about it. If he can truthfully answer that he knows nothing about it, we hire him. If he thinks he knows something about it, he will get in here and the first thing you know he will be telling others what he knows, and after a while they will all know that the problem cannot be solved. An expert is a man who knows all about a problem. That's why he's no use to us. We have to have men who not only don't know about it, but know they don't. We have to have what I call intelligent ignorance."

All of which will be startling to most readers. Yet it is almost exactly what Ford said several years ago in "My Life and Work," and it is what many another inventor has said. Are they all wrong? Or are the non-inventors and the non-discoverers right in thinking that originality in any field is to be looked for mainly in those who have spent many years working in that field?

Turning to the history of science (which, by the way few ever turn to) we find remarkable confirmation of the Kettering and Ford generalizations. Scientific history is literally crowded full of names of men who were not experts in the fields where their greatest discoveries were made. After a mathematician, like Isaac Newton, for example, has made a great astronomical discovery, the astronomers (rather tardily, to be sure) not only welcome him but make him a member of their astronomical societies, and thus he comes to be regarded by the public as an astronomer—as an astral expert. But watch such a discoverer, and note how often he turns to some other field of science, such as physics, and discovers other laws. Newton the star expert was Newton the sound expert, Newton the light expert, and Newton the mathematical expert. He made himself expert in whatever he studied, not in the sense of absorbing all that had been written on the subject of which it formed a part, but in the sense of first absorbing what was known about the particular problem that he attacked and then in learning more about that problem than any predecessor had ever known. If Newton is to be called an expert in the common sense of that term, he must be called, first, a mathematical expert, and, second, a research expert.

In selecting a jury for a criminal case, lawyers see to it that any one who has formed an opinion on the case shall not become a juryman. They seek unbiased minds. Evidently Kettering has found it equally desirable to secure unbiased minds to judge the merit of any new theory, and to do so by eliminating all experts except research experts. Since he employs both pure scientists and engineers, it is clear that he aims to secure not perfect ignorance on his "juries," but trained men who are intelligently ignorant. Obviously a man ignorant of mathematics will be greatly handicapped in trying to solve a problem in mathematical physics. But don't infer that such a man will be utterly useless. There was Faraday, for example, who was so ignorant of mathematics that in all his writings we recall not a single algebraic equation. Yet he framed a conception about ethereal undulations upon which Maxwell built his marvelous quantitative theory of ethereal waves, which Hertz later verified by producing the long waves that are today the foundation of a great business—the radio industry. So you see that even mathematically ignorant Faraday made a suggestion that a great mathematical genius seized and made so quantitatively definite that a laboratory experimentist was able to give it physical existence.

One of the objects of modern research laboratories is to bring a Faraday, a Maxwell, a Hertz, and a Marconi, and a DeForest together, there to perfect almost at one stroke a theory and a device that otherwise would remain undiscovered and uninvented for a generation or longer.

When a new scientific theory is first submitted, editors (scientific as well as otherwise) often ask some well known expert to advise them as to its probable truth. As a rule the answer is that the new theory is either too fantastical or too improbable to merit publication; for, as Kettering says, experts always know that the problem can't be solved that way. Yet listen to what a recent Nobel prize winner, Richardson, said years ago ("Electron Theory of Matter," p. 280): "Fitzgerald suggested that the null effect in the Michelson and Morely experiment was due to a change in the dimensions of the apparatus, just sufficient to counterbalance the expected effect (as to the velocity of light). * * * This hypothesis seems a wild speculation at first sight, but it appears, on further inquiry, that it is rather what might be expected to occur if matter is made up of electrons." And he goes on to tell how Lorentz, adopting Fitzgerald's "wild speculation," deduced a law that Einstein subsequently made famous, namely a law that shows how bodies shorten as their velocity increases, being squeezed to no length at the velocity of light. So the most marvelous development in mathematical physics that has occurred since Thomson discovered the electron about 30 years ago, resulted directly from a "wild speculation." Can't you picture the experts laughing Fitzgerald to scorn, particularly when he was unable to prove his hypothesis to be true? Yes, Kettering is right. Intelligent ignorance is a great desideratum, and, let us add ignorant intelligence is the bane of progress.

New Equipment and Materials

Recent Developments in Machines, Tools and Materials in the Water Works and Sewerage Field

New Pipe Handling Boom

A new pipe handling boom for mounting on the Model GH Trackson McCormick-Deering has been brought out by the W-K-M Company, Inc., Houston, Tex. It is of the live boom type. This new boom, which is known as the Model "AXM," is designed to handle longer lengths of pipe. It is stated to be sturdy in construction, well balanced, and properly mounted on the crawlers. The boom is installed and held close to the side of the crawler frame and the counterbalance weights are up out of the way, properly suspended on the opposite side from the boom. The result is greater lifting capacity with a minimum of counterweight.

On a recent pipe line construction job in the new East Texas field, the Model GH Trackson with this new W-K-M boom is stated to have handled up to 450 ft., or fifteen 30-ft. sections of welded pipe, at one time, without the use of a stiff-leg.

The W-K-M Model "AXM" boom is simple in design. It is easily installed

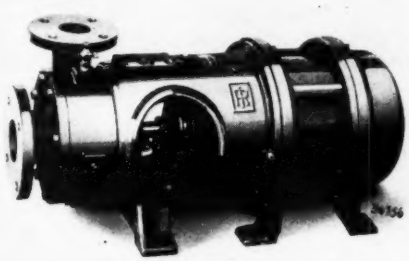
W-K-M Co. Model AXM Boom Mounted on Model GH Trackson McCormick-Deering Crawler Tractor

on the Trackson Crawler unit without any drilling or cutting. Also, all working parts are readily accessible. The unit is flexible and easily operated, requiring only one man, the tractor driver. Control levers are within easy reach, and friction clutches are provided throughout.

New Cameron Pump for General Service

A new Cameron general service centrifugal pump, designated as the Class "RV," is announced by Ingersoll-Rand Co., 11 Broadway, New York City. Both the pump and the electric motor that drives it are assembled together, producing a compact, lightweight, easily handled unit. This construction promotes dependability and reduces the needs for attention by minimizing the number of revolving parts and bearings and eliminating the use of a coupling.

The Class "RV" is designed for any pumping service requiring a small or medium capacity unit for operation against moderate heads. It is suitable for such



New Cameron Pump

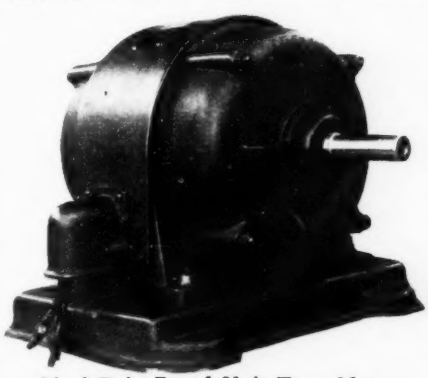
applications as circulating and cooling systems, standpipe and water supply systems in factories, warehouses and apartment buildings; and general transfer and handling service of any reasonably clear liquid.

This pump is made in six sizes and can be furnished mounted on a structural steel bedplate to facilitate installation, if so desired.

Ideal Announces the Drip Proof Unit Type Motor

The Ideal Electric & Mfg. Co., Mansfield, O., continues to add to its well rounded out line of Ideal motors of unit type construction. One of the latest developments is the Ideal drip proof motor which is protected against water or other liquids dripping on it or splashed in through the ends.

Large shrouded fans located just inside the end brackets at each end of the motor produce the action which discharges the water. These fans catch any water entering through the end of the motor and throw it against the inside surface of the bearing bracket. From



Ideal Drip Proof Unit Type Motor

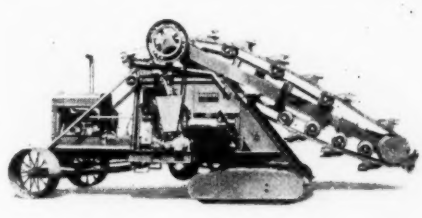
here the water runs down the inside of the bearing brackets and out through the center bottom vent without coming in contact with the windings.

Should water, through unforeseen causes, get beyond the shrouded fans, the insulation is so prepared that an occasional wetting will not have any serious effect. The strong blast of air which is continually being forced through the motor while in operation is more than sufficient to immediately evaporate any water that may reach the windings.

The outer surfaces of the Ideal drip proof motor are such that water dripping from above cannot enter the motor. The end bearing brackets are so shaped that water dripping on them travels around the end and to the base without entering the motor. The shroud cover encircling the motor at the center effectively prevents the entrance of water at this point. This cover does not completely surround the motor but is open at the bottom to form the exhaust vent through which both air and water are discharged.

New Parsons 35 Trencher Announced

The new Parsons Model 35 pipe line trencher embodying basically important features, is announced by National Equip-



New Parsons Trencher

ment Corporation, Milwaukee, Wis. The Model 35 offers these improvements:

1. An additional three speed transmission.
2. New heavy duty Kochring type cast steel multiplanes.
3. Wider conveyor belt, staunchly constructed.
4. Three foot longer, stronger frame.
5. Exceptional operating range and speed of excavation.
6. Typical N. E. C. quality construction.

The frame has been made 3 ft. longer, thereby allowing the introduction of an additional 3-speed transmission directly behind the engine, which gives three speed ranges throughout the machine. This feature is stated to make the machine adaptable to every soil condition, as any combination of speeds desired in the bucket line, traction and conveyor may be instantly accomplished. The extension of the frame also provides additional coun-

terweight without the addition of dead weight.

Koehring type Heavy Duty multiplanes having cast steel frames and self-cleaning tumblers have been installed. This multiplane is notable for its ruggedness and driving efficiency as the amount of traction power required has been materially reduced.

The conveyor has been equipped with a wider belt and the new design allows an effective dirt carrying width 6 in. wider than in the old design. The belt is equipped with guide clips that effectively prevent any movement of the belt off center. Cleats are also provided on this belt to prevent any possible slippage of material.

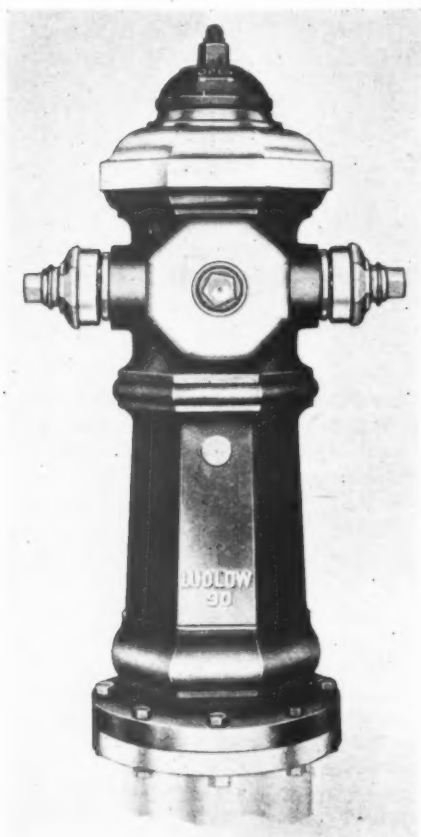
The fuel tank is equipped with a vacuum device by which the tank may be filled from a barrel standing on the ground and effectually prevents any spillage of fuel.

The Parsons Model 35 has an exceptional range as it can excavate to a depth of 15 ft. and up to 4 ft. in width. It is stated to be very fast in ordinary soils and is particularly well adapted to operate in rough country and in difficult soils including blasted lime rock.

Ludlow Brings Out New Fire Hydrant

The Ludlow Valve Manufacturing Co., Troy, N. Y., has introduced a new fire hydrant known as The Ludlow Diamond.

This hydrant has been designed to harmonize with the best surroundings. Conspicuous and ever necessary, the hydrant should be in keeping with modern street lighting standards, traffic towers and highway sign posts, which have already contributed so much toward making our streets attractive. The manufacturers recognized this, and also foresaw the importance of having one standard design that would embody the best thought in modern architectural treatments, and yet afford every practical advantage of the usual "pipe with nozzles." They made a thorough study of modern architecture and highway equipment before selecting this new octagonal shape. The shape offers another important advantage. The eight flat surfaces, especially on the dome and caps, provide eight light-reflecting planes. When the dome and caps are painted with aluminum paint, the hydrant becomes practically self-illuminating, and instantly locates and identifies itself even by day.



Ludlow Diamond Fire Hydrant

The body is not integral with the barrel, but ends in a flange which is bolted to the barrel flange just above the ground line. The bolt holes are so arranged that the hydrant nozzles can be set in any direction required, without disturbing the hydrant bottom or lead from the main.

It is in replacement work that this feature should be especially valuable. The hydrant body is so designed that any breakage caused by impact with a heavy truck, for instance, will occur just above the flange. By merely releasing 8 bolts here the old body can be removed and a new one substituted.

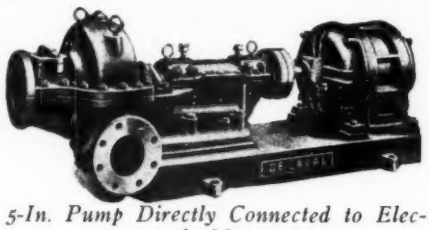
Certain changes have also been made in the hydrant bottom. This employs the famous Ludlow gate valve, the gate being lowered free and forced squarely against its seat by a wedge nut at the back of the gate. Through a few simple improvements in design, the lines of force are now opposed and directed downward, so that once the gate is closed with the drip valve open, it cannot be pulled free, and can be released only by turning the valve stem. Even if the hydrant body is broken the valve will not cause a flood.

Variations in grade can now be handled by selecting the proper length of connecting barrel. Since the hydrant body and bottom are standard for each size, it is merely necessary to stock a few of these in the proper sizes, as the correct depth is taken care of with flanged connecting barrels of suitable length.

Centrifugal Pumps for Liquid Carrying Solids

A new pump designed particularly for handling sewage, paper pulp and similar liquids has been developed by the De Laval Steam Turbine Co., Trenton, N. J. In this pump the casing is split in the plane of the shaft, with the discharge connection in the lower half, or casing proper. The casing cover can, therefore, be lifted off without disturbing the discharge pipe connection and after only partial unbolting of the suction pipe connection. When this has been done, all internal parts and passages are accessible, and the rotating element, with bearings, can be lifted out, after loosening the bearing cap. A large handhole, with easily removable cover, is located on the cover half of the suction nozzle, to give quick access to the suction side of the impeller for inspection and cleaning. The suction nozzle is designed for a large size suction pipe, insuring low pipe velocities and low total suction head, which is conducive to smooth and efficient operation of the impeller.

The lower half, or pump casing proper, has cast integral with it a pedestal or supporting foot, which is designed to be bolted directly to the bedplate of motor or engine driven units. The pump volute or body is overhung, making the piping connections easily accessible. The seats for the bearings, the packing gland and the sealing ring recesses are all bored at one setting, insuring perfect alignment.



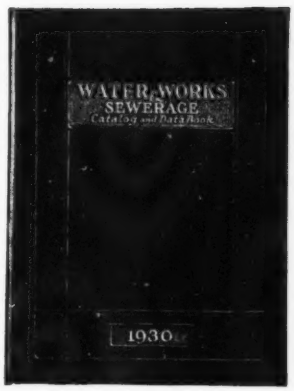
5-In. Pump Directly Connected to Electric Motor

The passages through the impeller are extra wide, both between the side plates and between the vanes. Ordinarily only two vanes are used, proper guiding of the liquid without cavitation or shock being attained by suitable selection of the speed and of the impeller diameter. By suitably proportioning the impeller passages and volutes, the pumps, which are operated at slow speed, have been made to compare favorably in efficiency with standard high speed clear water pumps. Where the pump capacity or the nature of the liquid permits, the number of impeller blades is increased to three or four, permitting of higher speed.

At the joint between the impeller and casing, the impeller is protected by a bronze ring threaded upon it, while the casing is protected by a stationary bronze ring seated in recesses formed in the casing and casing cover and, therefore, removable when the cover and rotor are lifted. A circumferential slot in the stationary ring communicates with a tapped opening through the casing cover to provide for sealing with clear water under a pressure slightly higher than that generated by the pump, in order to prevent liquid and abrasive matter handled by the pump from entering between the rings.

For some services an open impeller is used, with removable stationary side plates of special form held in recesses in the pump casing and cover to guide the liquid during its passage through the impeller. The knife-like edges of the impeller blades, running close to these side plates, cut or shear stringy material. The efficiencies obtained are very nearly equal to those of the enclosed impellers.

In order to avoid too great overhang of the shaft, the stuffing box is located over the impeller hub, which is protected by a renewable bronze sleeve.



THAT HE WHO SPECIFIES MAY READ - - -

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Chicago, Illinois

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DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Dorr-Oliver Corporation Formed by Two Well-Known Firms

Announcement has been made by John Van Nostrand Dorr and Edwin Letts Oliver of the union of the businesses and assets of the Dorr Company and Oliver United Filters, Inc. The new company will be known as Dorr-Oliver Corporation and will be under the joint management of Messrs. Dorr and Oliver.

The new corporation will function through its two wholly-owned operating units, each directed by its respective head with the continued aid of their present executive and technical staffs.

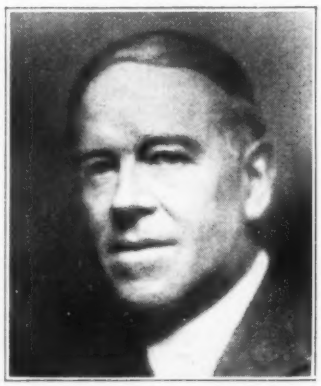
The businesses of the two uniting companies are of long standing and complementary. The Dorr Company occupies a leading position in the fields of agitation, classification and sedimentation through its equipment, built up around the inventions of Mr. Dorr, and the Oliver company occupies a similar position in the field of filtration through the inventions of Edwin L. Oliver and E. J. Sweetland. It is, therefore, expected that through the union a more complete line of equipment and engineering can be offered to the industry than either company could offer separately.

Both companies have followed constructive policies of development and research, and the fields are so closely related that it will be possible to carry on joint research resulting in more effective development and improvement of equipment. The common use of the technical staffs and manufacturing facilities of each company located throughout the world will make for more efficient service to the clients of both.

John Van Nostrand Dorr was educated at private schools and Rutgers University, from which he received the degree of Bachelor of Science in 1894. Honorary degrees were conferred upon him in 1914 and 1927. He began his professional career as a chemical experimenter with Thomas A. Edison, and later worked in South Dakota as assayer, chemist, operator and research worker. From 1901 to 1913 he worked as a consulting metallurgist and designer and operator of mills and mines.

In 1913 he founded The Dorr Company of which he became the president. He is the inventor of the Dorr classifier, thickener, agitator and many modifications thereof used in metallurgical, chemical, industrial and sanitary fields. In 1916 Dr. Dorr was awarded the John Scott medal of Franklin Institute, "For his hydrometallurgical apparatus extensively used in the cyanide (gold and silver extraction) process"; and in 1929 the James Douglas medal of American Institute of Mining and Metallurgical Engineers for "his invention of apparatus and achievement in developing and improving hydrometallurgical practice."

John Van Nostrand Dorr



Edwin Letts Oliver

Dr. Dorr is a member of the Mining & Metallurgical Society of America; American Institute of Mining and Met. Engineers; American Electro-Chemical Society; Inst. of Mining & Metallurgy (London); Canadian Inst. of Mining & Metallurgy; So. African Chemical, Metallurgical & Mining Society; president of the United Engineering Trustees, and vice-president of American Institute of Chemical Engineers. He is a trustee of Rutgers University, a trustee of Greenwich House Music School (New York,) and national president of Zeta Psi fraternity. His clubs include: Century, University, Engineers, Chemists and Zeta Psi, all of New York; Cosmos, Washington; Royal Automobile, London; and Circle Interalle, Paris.

Edwin Letts Oliver graduated from the University of California in 1900 and immediately entered upon his career as a metallurgical engineer and manufacturer. He began work in cyanidation in the Grass Valley mining district in California, and designed and supervised the construction of two cyanide slime plants of the North Star Mines Company, and was metallurgist for it until 1910.

About 1908 Mr. Oliver invented the Oliver continuous filter for handling cyanide slimes. Impressed with the outlook for the filter manufacturing business he resigned in 1910 from the North Star Mines Company and embarked upon the manufacture and sale of the Oliver filter for cyanide slime plants. The entire sales and office staff consisted of one man, R. Gordon Walker, the present general sales manager of Oliver United Filters, Inc. Factory facilities were supplied by contracting the work with a machine shop owned chiefly by Oliver's father. He later purchased this shop which was the forerunner of the present Oliver factory in Oakland, California.

Meeting with success, the filter was rapidly adapted to use in similar problems in other industries. Just before the World War, a great impetus was given to the filter business by the newly exploited flotation process, and war-born activities extended the use of the filter into industrial chemical fields. This adaptation for other work received early recognition by a gold medal and awards at the Pan-American Exposition in 1915.

In 1917 it became necessary to open an office in New York due to rapidly increasing business after the beet-sugar industry adopted the Oliver filter generally. This was followed by a London office in 1920, and in 1922, Mr. Oliver, who up to that time had been handling the business as an individual, incorporated as the Oliver Continuous Filter Co.

In 1923-24 the use of the filter was extended to the handling of sewage sludge. From the original simple type, the filter now embraces several hundred different combinations.

In 1928 the Oliver Continuous Filter Company and the United Filter Corporation, consolidated to form the Oliver United Filters, Inc., with Edwin Letts Oliver as president and active head.

In spite of his world wide interests, Mr. Oliver has always had his home in California, where he was married and where his four children were born and educated. His father, William Letts Oliver, was a noted mining engineer in the '70's and '80's. He established an explosives factory in 1880 which is operated today by his heirs as the California Cap Company. Association with his father's activities gave to Edwin Oliver much valuable training during his school years as well as later in life.

Outside of his business responsibilities, Mr. Oliver has many and varied interests. He is a member of Delta Upsilon college fraternity, Sigma Gamma Epsilon and Sigma XI honorary scientific society, and was awarded the honorary degree of Engineer of Mines by his university. He is also a member of A. I. M. & M. E.; The Mining and Metallurgical Society, the Chemical Mining and Metallurgical Society of South Africa, and for years has served on the administrative boards of his university.

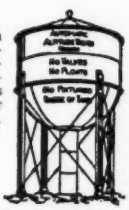
He has a keen sense of human values, is an ardent sportsman, being a yachtsman, golfer and horseman and an enthusiastic supporter of other sports.

WATER CONTROL

without floats or fixtures

A constant water level can be automatically maintained in reservoirs, tanks and standpipes by the use of

GOLDEN-ANDERSON Automatic Cushioned Controlling Altitude Valves



These valves are always cushioned in closing and opening. They are extensively used for automatically maintaining a uniform stage of water in reservoirs, tanks and standpipes. No valves inside. No floats or fixtures, inside or outs.de of tanks. No freezing troubles. Three ways of closing these valves:

1st—Automatically, by water
2nd—By electricity, if desired
3rd—By hand

Remember: Valves cushioned at all times by air and water. No water hammer or busting mains.

"Made with stop starter attachment for centrifugal pumps."

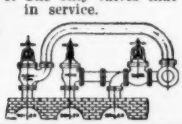
Golden-Anderson Valve Specialty Co.

1385 Fulton Bldg., Pittsburgh, Pa.

"4575"
Used by Steel Cos.

Pat. Automatic Double Cushioned Triple Acting Non-Return Valves

1. Prevent shutdowns due to reversal of steam flow.
2. Instantly close and isolate a boiler when a tube bursts.
3. Cut off steam flow from every boiler instantly when a steam pipe ruptures.
4. Automatically cut a boiler into line.
5. Prevent backflow into cold boiler.
6. The only valves that can be tested in service.



Angle, Globe or Elbow

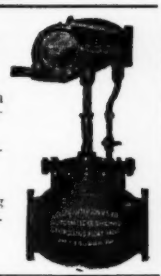
Patent Automatic Cushioned Controlling Float Valves

They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water. Operate without hammering, sticking or chattering. No metal-to-metal.

Sizes 1 in. to 24 in.



Patented Cushioned Electric Water Service Valves

Especially adapted for Diesel Engine cooling.

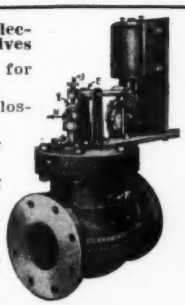
Quick opening and closing.

No water hammer or shock.

Cushioned in opening and closing.

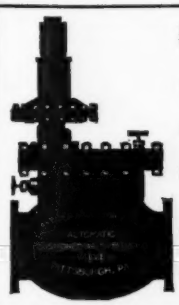
For A. C. or D. C. circuits.

Size 2 in. to 24 in. in angle or globe patterns.



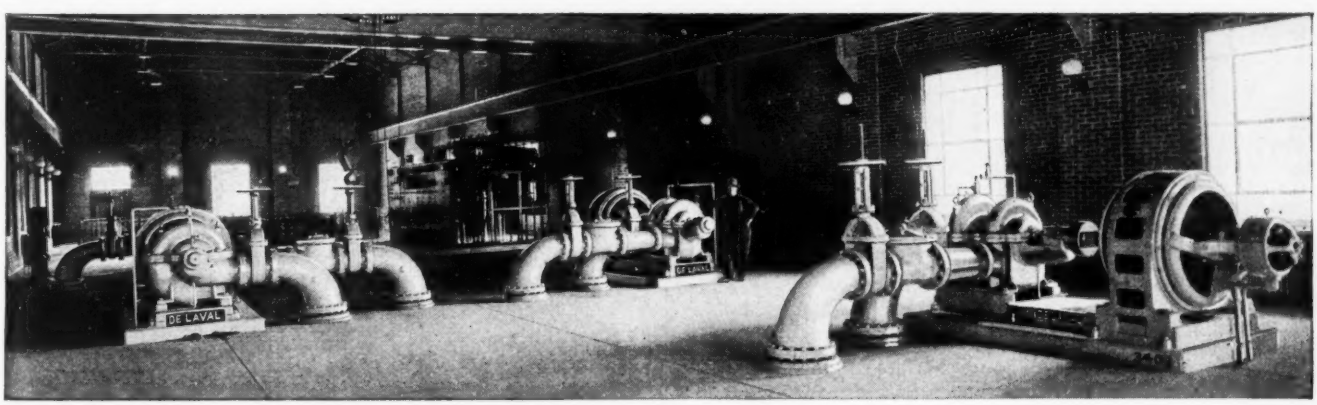
Pat. Automatic Cushioned Water Float Valves

1. Automatically maintain uniform water levels in tanks, standpipes, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—most satisfactory float valves known.
4. No metal-to-metal seats — no water hammer or shock.
5. Cushioned by air and water.



Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 inches.



De Laval Pumps Provide Low Cost Water Supply for Hagerstown, Md.

HAVING outgrown its original mountain water supply, the city of Hagerstown, Md., has installed a modern pumping and purification plant of 10,000,000 gals. daily capacity, to take water from the Potomac River. The main high pressure pump room, which is here shown, contains three motor driven De Laval two stage pumps having a capacity of 3,500 gal. per min. each against 400 ft. static head. The low service pumps lifting water from the river are also of De Laval manufacture. The average operating cost for a year, including power, labor, chemicals and all other expenses, has been $39.97 per million gallons pumped.

De Laval Steam Turbine Co., Trenton, N.J.

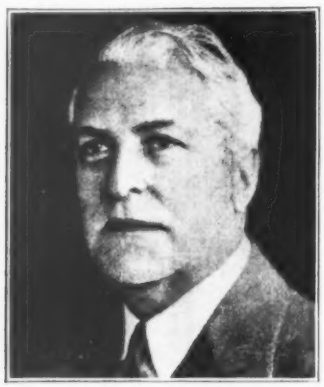
4032

Dresser Company Shows Steady Growth for 50 Years

An industry started in a modest way at Bradford, Pennsylvania, fifty years ago by S. R. Dresser now occupies a plant covering more than seven acres of land and with a floor area in the buildings of approximately 120,000 square feet.

Solomon R. Dresser founded the business in 1880 to manufacture an oil and gas well packer of his own invention, the principles of which are said never to have been essentially altered. He also made sucker rods and oil producing equipment. S. R. Dresser Manufacturing Company is now one of the largest manufacturers of pipe couplings and accessories.

Mr. Dresser was a close student of oil and gas transportation and was imbued



F. A. Miller, Chairman of Board, S. R. Dresser Mfg. Co.

with the possibilities of the largest cities one day being supplied with natural gas from fields hundreds of miles away. To make this service possible Mr. Dresser started experimenting to secure a joint which would incorporate flexibility, durability and permanent gas-tightness. The result of this work was the Dresser coupling in use today.

To prove the merit of his invention Mr. Dresser entered the natural gas business, operating under the name of the Malta and McConnelsville Company and laid a gas line five miles long at Malta, Ohio, equipping every joint with a Dresser coupling. This was in 1891, and from that time on the business of the company enjoyed steady growth.

In 1905 the business was incorporated as the S. R. Dresser Manufacturing Company, with Solomon R. Dresser as president and F. A. Miller as secretary-

H. N. Mallon, President and General Manager, Dresser Company

treasurer. In addition to these officers the first directors were George P. Boothe, Caroline K. Dresser and R. A. Dresser.

In 1907 it became necessary to build a larger and more up-to-date plant, and this has been enlarged and modernized from year to year until today it is said to be the largest of its kind in the world devoted exclusively to the manufacture of pipe couplings and accessories. Approximately half a million dollars was expended on the plant and equipment in the latter part of 1929 and the early part of 1930, and it is said that by August 1st, 1930 the production capacity was nearly three times as great as during 1929. The buildings are of brick and corrugated steel construction and equipped largely with hydraulic machinery.

Engineers and officials of water works concerns became familiar with the Dress-

Merrill N. Davis, Vice-president in charge of sales

er couplings and tried them out. The output in this field is said to be steadily growing as one company after another makes installations of water lines making use of the Dresser products. The research and engineering department is constantly investigating the needs of the market served and frequently suggests changes to render the product adaptable to special conditions.

Until the death of Solomon R. Dresser in 1911, the management of the company remained unchanged. Mr. Dresser was succeeded as president by F. A. Miller, and Clyde C. Comfort was made the new secretary-treasurer. Under Mr. Miller's leadership the company continued to prosper, and by 1919 his executive duties had become so many and varied that Merrill N. Davis, formerly with the B. F. Goodrich Rubber Company, was appointed as his aide. Mr. Davis had a thorough knowledge of the pipe line business and great faith in the merits of the Dresser products, and his amazing capacity for work made him an invaluable asset to the company.

In 1929 the capital structure of the company was changed and its securities were distributed among employes and others, and the stock was listed on the New York Curb Exchange. At this time Mr. Miller was made chairman of the board, and H. N. Mallon president and general manager and Merrill N. Davis was advanced to vice-president in charge of sales. Mr. Mallon joined the company after a broad experience in industrial management, and extensive travels. During the World War he served in the United States artillery and it is said that he was the youngest major in the U. S. A.

Minnesota Governor Names Four Appointees

Arthur S. Milinowski, engineer of Stillwater and St. Paul has been appointed to the board of health to succeed L. P. Wolff. Frederic Bass, member of the engineering faculty of the state university, has been named to succeed Dr. S. Marx White of Minneapolis, and Dr. C. I. Oliver, Graceville, to succeed Dr. O. F. Melby, Thief River Falls. All of these appointments will expire in January, 1934.

Dr. Iver Silvertsen, Minneapolis, was named to the medical examining board for a term ending May 1, 1938. Governor Olson announced the reappointment of F. E. McKillip, Faribault, as a member of the state board of registration for architects, engineers and land surveyors. His term will run to January 1, 1935.

The Home of Dresser Couplings, Bradford, Pa.

PITTSBURGH DES MOINES

Two Million Gallons— *That's a Lot of Water!*

Until late summer 1930 the City of Columbus, Ohio, was confronted with a distinct and threatening water supply problem. Peak load demands and a prolonged drought cut heavily into available water reserves and pressures to outlying supply mains were seriously reduced. Domestic service complaints mounted.

In September, 1930, "Pittsburgh-Des Moines" completed the erection of the above two identical 1,000,000 gallon capacity hemi-ellipsoidal tanks. The tank shown at the left is in North Park; the tank at the right is ten miles distant in West Park.

This 2,000,000 gallon reserve of water is *always there*—at a strong gravity pressure—for domestic supply, adequate fire protection and other municipal uses—a comforting assurance for emergencies and droughts.

Our thirty-eight years' experience in the municipal contracting field may help to solve *your* problem.

QUALITY TANKS

Other "Pittsburgh-Des Moines" Products

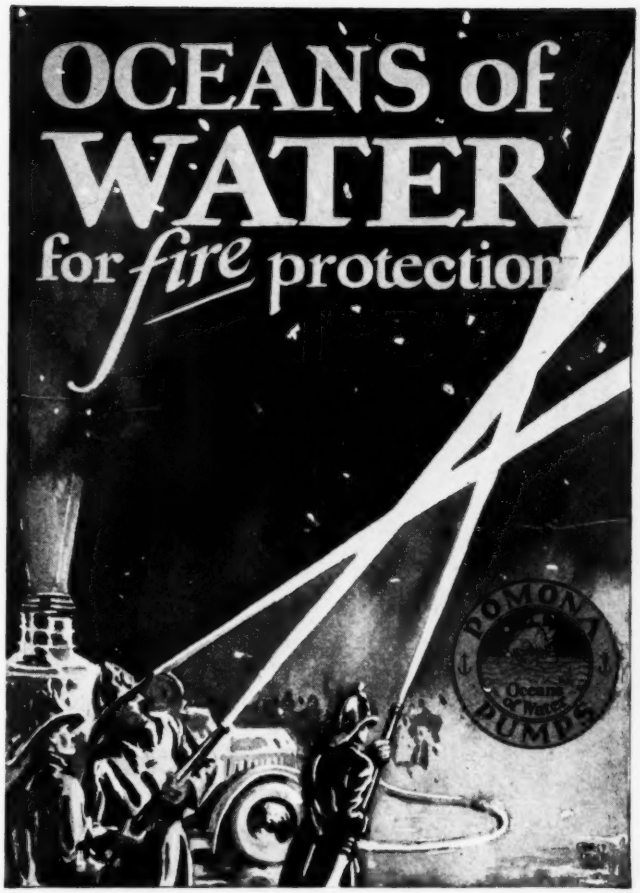
Steel Reservoirs	Complete Water Works Systems
Steel Standpipes	Water Treating Plants
Steel Pipe Lines	Gasoline and Oil Tanks
Structural Steel Work	Municipal Incinerators
Highway Bridges	Steel Grandstands

General Steel Plate Fabrication

Pittsburgh-Des Moines Steel Company

3418 Neville Island, Pittsburgh, Pa.
919 Tuttle St., Des Moines, Ia.

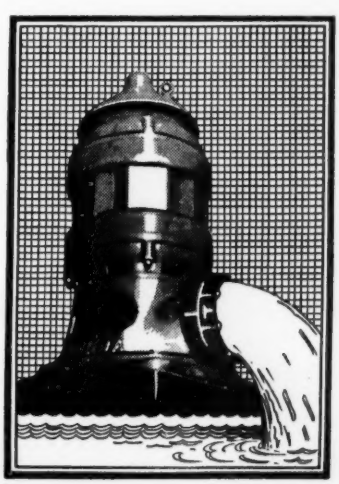
New York Chicago Dallas Atlanta
Seattle San Francisco



Pomona Water-lubricated Turbine Pumps keep reservoirs and pipe-lines brimful of water to meet emergencies all the time such as fire, drought, etc. Amazing performance and stamina are built into these pumps by scientific design and modern manufacturing methods. Water can be lifted from underground and boosted to elevated reservoirs without additional pumping equipment. Quiet and vibrationless operation is assured by the use of Goodrich Cutless bearings at every shaft contact point below the surface. Other indispensable factors that assure longest life include: variable capacity impellers adjustable from surface; non-corrosive stainless steel pump shafts; built-in Westinghouse motors; and true alignment throughout the pump. Capacities, 15 to 5000 g.p.m.

WATER-LUBRICATED

Distributors, factory representatives and service facilities in all principal cities. Name of nearest one and Bulletin on request.



POMONA PUMP CO.
POMONA, CALIF.

POMONA TURBINE PUMPS

Quammen Appointed District Manager for Cutler-Hammer

D. J. Quammen, who has been connected with the Philadelphia office of Cutler-Hammer for the past five years as a sales engineer, has been appointed manager of the district, according to recent announcement. Mr. Quammen succeeds F. J. Burd, who has been made assistant manager of the Chicago office of this company. Mr. Burd will have charge of industrial sales in the Chicago district, and of the C-H (Harland) paper machine drive, throughout the country.

D. J. Quammen

Mr. Quammen graduated with the class of 1924 from the University of Wisconsin with the degree of B. S. in Mechanical Engineering. He has proven his ability as a motor control engineer and is well fitted for his new position.

McWane Transfers Eastern Offices to New York

The McWane Cast Iron Pipe Company announces the removal of its eastern sales offices from Philadelphia to 40 Exchange Place, New York, Suite 1408 Lord Court Building. Porter W. Allen, for the past several years in charge of the offices in Philadelphia, is also removing to New York, where he will continue as Eastern sales manager for the McWane interests.

The reason given for the move is the growing concentration of water works material buying in the hands of utility organizations with headquarters in New York. It is also stated that the new arrangement will enable the company to maintain a closer touch with its New England representation and clientele, without lessening its contact with important customers in the Philadelphia area.

Bacon Heads Pump Division Fairbanks-Morse Company

R. H. Bacon, formerly advertising manager of Fairbanks, Morse Company, has been appointed manager of the pump sales division with headquarters in Chicago, according to recent announcement.

Mr. Bacon joined the company in 1925

R. H. Bacon, Manager Pump Sales Division, Fairbanks, Morse Co.

to take charge of publicity for the Diesel engine division, and shortly thereafter was placed in charge of general publicity, and in 1929 became manager of the advertising and publicity department.

For three years previous to entering the Fairbanks, Morse Company he was associate editor of Power Plant Engineering, and prior to that time was assistant engineering editor of Electrical World. He is a graduate electrical engineer of the class 1916, University of Illinois, and for three years was assistant electrical engineer for the Copper Range Mining Company.

His training and past experience ably fits Mr. Bacon for his new duties in directing the marketing of F-M pumping equipment.

Natural Hot Water

The U. S. Piper for June told an unusual and interesting story of the piping of natural hot water into Boise City, Idaho, by The Natatorium Company. The wells from which this water is taken have been in operation for forty-one years. The original pipe lines were made of wood, but in 1896 metal lines were installed to serve all the consumers with hot water for both heating and domestic purposes. An installation of de Lavaud centrifugal cast iron pipe has recently been completed under the direction of E. E. Smith, manager.

Temperature at the wells is 170 degrees F. and it is said that this temperature has never varied winter or summer. The daily supply is given as 1,200,000 gal. In 1930, 213 consumers were supplied with hot water for heating purposes and 70 in the summer with hot water for domestic purposes.

The editor of *The U. S. Piper*, Ralph M. Shaw, Jr., announces a new pamphlet on "Specifications for cement lining of cast iron pipe and fittings," which he will be glad to mail to interested engineers or contractors. Mr. Shaw's address is U. S. Pipe & Foundry Co., Burlington, N. J.

Cutler-Hammer, Inc., have located their sales office in Atlanta, Georgia, at 133 Cone Street, N. W. The new quarters will include warehouse facilities where a stock of the C-H motor control, will be carried for immediate delivery. A. C. Gibson is manager for the Atlanta district.

Stuart Joins Industrial Chemical Sales Co.

According to recent announcement, Fred E. Stuart has resigned his position with the City of Daytona Beach, Florida, to represent the Industrial Chemical Sales Company, Inc., in the sale of their Nuchar activated carbon for water purification. Mr. Stuart has been active in water softening and allied sanitary field for the past few years in Florida. His services and experience are at the disposal of any water works officials who have problems with water purification which they may desire to eliminate.

Fred E. Stuart, Water Purification Division, Industrial Chemical Sales Company, Inc.

Such rapid advancement has been made by the use of activated carbon in the field of water purification for the elimination of tastes and odors and other similar annoyances, that the makers of Nuchar have placed trained men in the field in line with their policy of aiding their patrons in the most efficient manner.

E. L. Luaces, Technical Staff, Industrial Chemical Sales Company, Inc.

E. L. Luaces of the technical staff of Industrial Chemical Sales Company attended the convention of the American Water Works Association with Mr. Stuart, to render service to those interested in solving problems of water purification, particularly with reference to taste and odors.

Hellige, Inc., is the corporate name of the company formerly known as Hellige-Klett, Inc. This company, makers of scientific instruments, laboratory and bacteriological supplies, is located at 179 East 67th St., New York.

WATER WORKS AND SEWERAGE

JULY 1931

VOL. No.

A GILLETTE PUBLICATION

CORRECTING FOR ERRORS CAUSED BY MANGANESE IN THE RESIDUAL CHLORINE TEST

By LINN H. ENSLOW

Research Engineer, The Chlorine Institute, Inc., 30 East 42nd St., New York City

MANGANESE in the reduced state, as usually found in water supplies, does not give a color with ortho-tolidin or other reagents used in testing for residual chlorine. Upon addition of chlorine, all or some part of the manganese present will be oxidized to the manganic state and thereafter will produce a false test indicating more residual chlorine than is actually present. Because of this it is unsafe practice to assume that all of the color in the residual chlorine test is due entirely to chlorine *even though the same test applied to the water prior to chlorination produces no color.* Likewise it is incorrect to assume that the apparent residual chlorine value, if any, that is secured by test of the unchlorinated water is the total correction which should be deducted from the *apparent* residual in the chlorinated water. This for the reason that probably only a part of the manganese may be present in the oxidized state in the unchlorinated water whereas chlorination increases the proportion of manganic manganese content and the false color. The presence of nitrites may likewise be responsible for a color prior to chlorination which, after oxidation by chlorine, produces no false color test in chlorinated samples.

On the whole there are so many errors that might be encountered when determining the "blank" on the unchlorinated water for deduction from the *apparent* residual chlorine content in the chlorinated samples, that it seems essential to reduce the chance of error to a minimum by making a "blank" determination on the water *after* chlorination whenever substances capable of producing a false color with orthotolidin are suspected of being present.

The following method is being used until one more accurate, but as practical, is available. The test is open to criticism in some respects but has the desired value of simplicity. The errors involved have not so far been found sufficiently great to interfere with the practical aspects of chlorine dosage control by the residual chlorine method.

Procedure.—The sample of chlorinated water is allowed to stand for a period sufficient to represent the contact time available between the point of chlorine application and the point of sampling for dosage control. Samples collected from distribution systems naturally require no further contact period and the same will apply in actual sampling for chlorine control where the contact period in the pipe line, etc., has already exceeded 15 minutes.

Test A: Determine residual chlorine content as usual, regardless of the contact period allowed after the addition of the ortho-tolidin before comparison is made with the standards. The contact time at which maximum color is observed should be used by preference. Occasionally 15 minutes may be required.

Test B: Boil a portion of the sample vigorously for 5 minutes or even longer. (It should be sufficient in any case to boil off 25 cc from a 100 cc sample.) Cool to room temperature or slightly lower and make up to original volume with distilled or any other manganese free water. Determine the false residual chlorine

"blank" in the identical manner employed in test "A" above, or as is the practice routine testing.

The reading "B" subtracted from "A" gives, for all practical purposes, the correct residual chlorine content. The reading on the boiled sample—the "blank"—is the error caused by substances other than the residual chlorine which has been consumed or driven off by boiling prior to the test.

Notes.—(a) Should a precipitate appear on boiling it will be necessary to add more ortho-tolidin reagent, or additional acid to cause its re-solution, since the precipitate may contain some manganese. Manganese has a tendency to deposit on glass surfaces. To insure against an error due to manganese deposition on the sides of the vessel during boiling it will be advisable after transfer of the boiled sample to add some ortho-tolidin solution to the vessel used. If a yellow color appears, wet the sides of the vessel thoroughly with ortho-tolidin solution and fill to 100 cc with manganese free water. Evaluate the color in terms of residual chlorine and add this to the "blank" from the boiled sample.

(b) Do not acidify the water sample before or during boiling. A double reaction occurs which reduces the oxidized manganese and the "blank" may be zero, whereas neutral or somewhat alkaline samples of the same water may show an appreciable "blank" after boiling. Acidification, if required, should be carried out after cooling down the boiled sample.

Remarks.—The North Jersey Water Commission laboratories located at Wanaque, N. J., do not employ the boiling procedure for estimating the manganese "blank" because at times the unchlorinated water will show a positive test for residual chlorine which boiling seems to dissipate. The error thus caused has reached a maximum of as much as 0.1 p.p.m. residual chlorine. If the same error carries through to the chlorinated it would result in somewhat less residual chlorine being carried than that indicated from the boiling out test. This loss, however, may be actually determined by testing the unchlorinated water and if of consequence can be added to the "blank" observed when the boiling procedure is used on chlorinated samples. What compound is responsible for the color produced in the raw-water with ortho-tolidin and is dissipated on boiling has not been determined.

At the Wanaque laboratories, A. E. Griffith, Chemist in Charge, prefers to completely oxidize all manganese in the unchlorinated water samples by a procedure suggested by Forman (*). The sample is made strongly alkaline with caustic soda and oxidized by displacing the air in a bottle above the sample with oxygen from a cylinder of the gas then stoppering and shaking violently. The oxidized sample is then neutralized or slightly acidified and thereafter the customary volume of ortho-tolidin solution added. The maximum color produced is recorded in terms of residual chlorine and constitutes the "blank" which is deducted from the apparent residual chlorine found in the chlorinated water. The "blank" multiplied by 1.25 is also recorded as p.p.m. manganese (Mn) present in the sample.

If anything, the "blank" as determined is high rather than low, and therefore an error will be on the safe side in as much as the residual chloride actually present can not be less than that found by the use of this procedure. Another way of putting it is that should the total manganese not be 100 per cent oxidized by the chlorine at the instant of making the residual chlorine test, then the deduction of the "blank" determined by the complete oxidation procedure will give a residual chlorine value lower than is actually present. For this reason the method, even though subject to this error, precludes the possibility of deficient chlorination.

The use of the Forman procedure is practical where facilities for employing it are available. Under different circumstances, however, the simpler boiling procedure will prove more practical and should prove to be sufficiently dependable for the purpose intended even though it be open to scientific criticism.

For greatest dependability its application should include a test for apparent residual chlorine in the unchlorinated water. If appreciable, it should be recorded and a sample which has been boiled should be also tested. If the loss in apparent chlorine content after boiling has been appreciable this loss should be added to the "blank" recorded for the boiled chlorinated water.

*L. Forman—"Manganese in Water Supplies"—Jour. A.W.W.A. 21: 1212, Sept. 1929.

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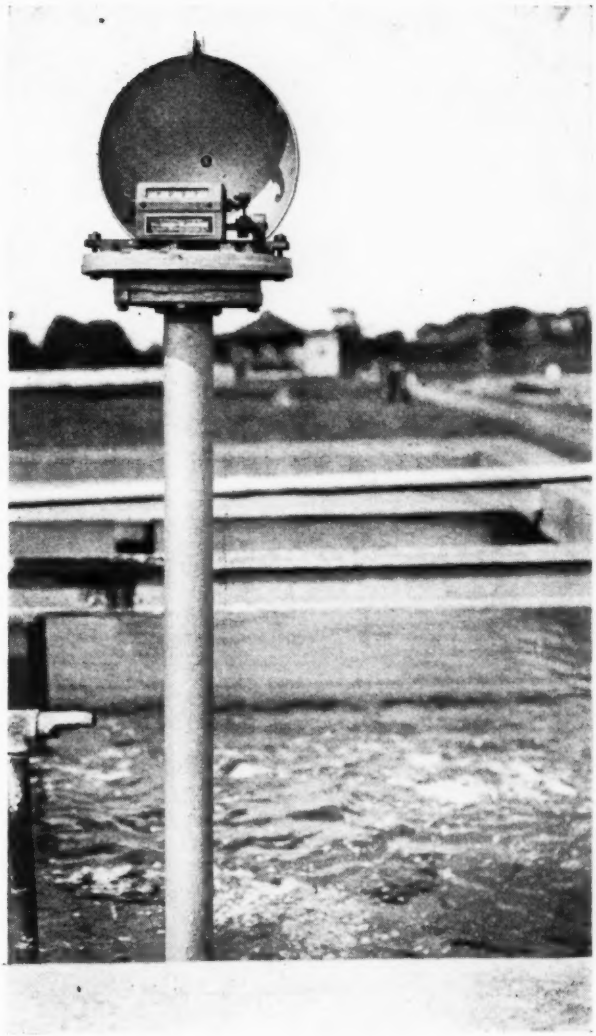
Order of State Board Regarding Pollution of Waters Sustained

The Supreme Court of Rhode Island in a decision handed down on March 13 sustained an order of the State Board of Purification forbidding the discharge of sewage by the Town of Bristol into the water of Bristol Harbor. Public Health Reports for May 15 comments on the case as follows:

The State Board of Purification of Waters, after an investigation and a public hearing, found that the pollution caused by the discharge of sewage by the Town of Bristol into the waters of Bristol Harbor constituted a menace to public health. An order of the board directed the town to adopt, use, and operate properly some practicable and reasonably available system or means to prevent such pollution and to submit to the board a plan or statement describing the system or means which the town proposed to adopt. The town appealed from this order on the ground that the same was unlawful, it being claimed that the board had no authority to regulate or prohibit the discharge of sewage by the town into the public waters of the state.

By chapter 936 of the Public Laws of 1901, the Town of Bristol was authorized "to convey sewerage into tidewater." By a statute enacted in 1920, the Board of Purification of Waters was created and was given authority to regulate or prohibit the pollution of the waters of the state, including all tidewaters and the inland waters of any stream or pond. The act was operative throughout the state, except that it did not apply to sewage discharged by the City of Newport and the Town of Jamestown. By a decision of the supreme court, rendered in 1926, this act was held to be a valid exercise of the police power of the state for the protection of the public health and the public welfare. By chapter 1451 of the Public Laws of 1929-30, chapter 936 of the Public Laws of 1901, relating to the Town of Bristol, was amended. The purpose and effect of the amendment, as stated by the supreme court, were to validate an unauthorized appropriation for sewage purposes previously made at a financial town meeting. The supreme court held that the 1920 act, respecting the Board of Purification of Waters, revoked the authority previously given to the Town of Bristol for the disposal of its sewage, and that such authority was not revived by the amendment of the 1901 act made by chapter 1451 of the 1929-30 laws. The order of the board was sustained.



Counter Mechanism of the Diving Bell Type Counter

GAUGING SEWAGE FLOW THROUGH A CONTINUOUS-FLOW DOSING TANK

By MORRIS M. COHN

Sanitary Engineer, Department of Public Works, Schenectady, N. Y.

SEWAGE treatment is a large-scale business. The income is, figuratively, the volumes of crude sewage delivered to the preliminary and secondary treatment devices. The outgo is the effluent which enters the diluting stream. The net profit of operation is the solids captured by grit chamber, by rack, by fine screen, by tank and the bacteria destroyed by disinfection. The "good will" is, perhaps, the more intangile conversion of highly putrescible materials in the sewage into innocuous compounds. The big business must satisfy the demands of the trade. The sewage-works which is a "going concern" has a biochemical oxygen demand to satisfy.

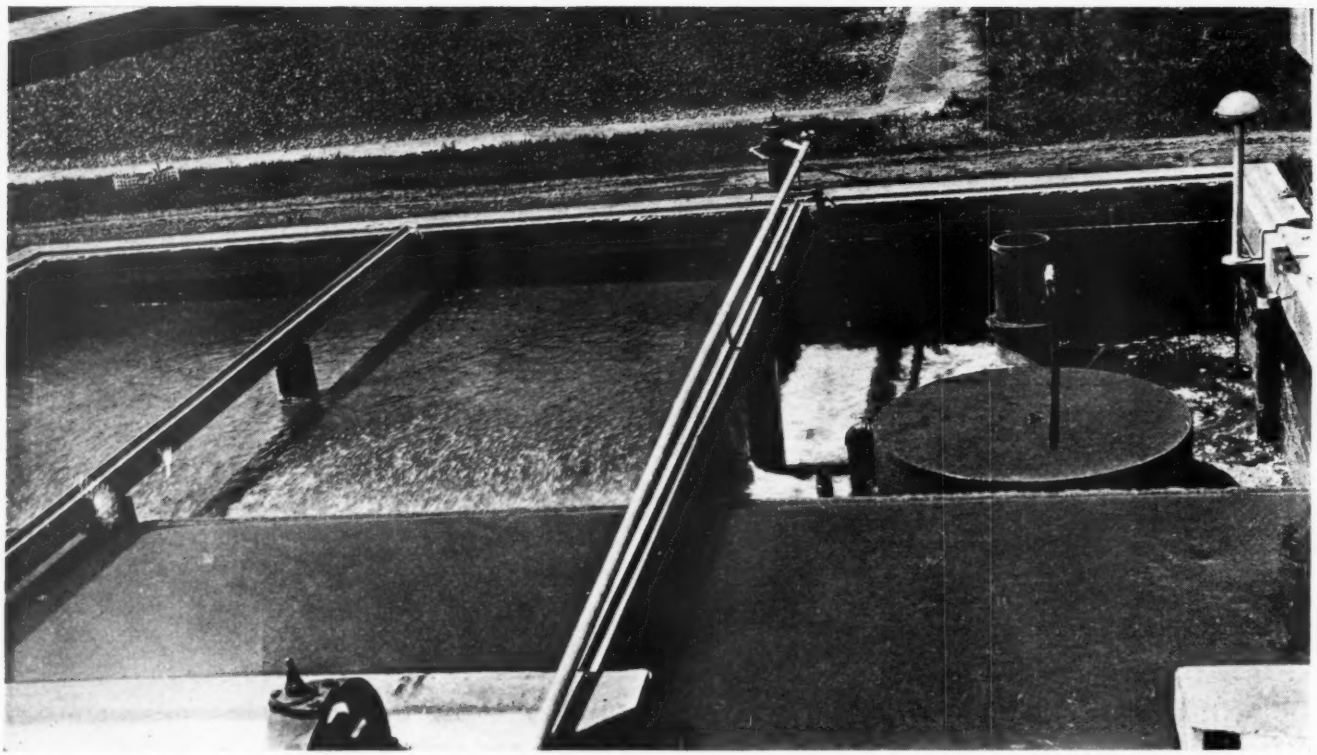
This is a rather homely way to look at the homely problem of treating the most dangerous wastes of life which a community produces. Nevertheless, the simile can be carried still further. The cash register must record the gross sales transacted by the business. The sewage-works, if it has passed beyond the stage when tradesmen counted beads to compute charges, must provide modern means for registering the amount of sewage flow passing through treatment units. It is axiomatic that knowedge of flow conditions is necessary for the intelligent operation of plants and the interpretation of results of operation.

The designer of a treatment plant, no matter how small or how large, is instantly confronted with the question of sewage quantities to be treated and at what variable rates this quantity will come down through the trunk sewer. The operator of that plant is constantly faced with the question of sewage flows. Anyone who has attempted to wade through the mathematical problem of balancing the amount of sewage solids deposited in tanks as computed from the suspended solids removed by the units and the sewage flow passing through, against the pounds of solids removed from those tanks computed from the yardage of sludge removed and the solids content of the material, well knows the value of flow records. Fortunately, the majority of the modern plants are being provided with flow meters of efficient design which indicate, register and record all flow fluctuations.

Flow Gauging in Dosing Tanks.—There are still in existence, however, many installations where the operator is estimating sewage flow from the water pumpage records, from piston displacement in sewage pumps, from the persons connected to the sewerage system or by means of measurements of discharge head over all types of weirs. The dosing tank tributary to filters has ever offered opportunity for flow gauging in plants where no other means is provided. Even at installations where the total flow is satisfactorily obtained from meters, the dosing tank offers the possibility of determining how the flow is being split up through various treatment batteries in the plant proper.

Where the flow into a dosing tank is not continuous, during periods of fill and empty of the chamber alike, the problem of flow measurement is simple. Having given the capacity of the tank between high and low water levels and the number of times it has filled as obtained from a counter, the flow passing through the preliminary and secondary units connected to the dosing tank will be known. This simplicity applies to such installations where twin dosing tanks are used and one tank fills and is then cut out of service during the emptying period while the other tank receives the flow.

The dosing chamber into which the flow is continuous offers greater difficulty to the flow gauger. Here the



Dosing Tank, Schenectady, N. Y., Showing Receiving Channel and Siphon Chamber. Note the Diving Bell Type Dosing Chamber

sewage continues to enter the siphon chamber during the discharge period of the siphon and influences the dosing cycle of the siphonic apparatus. The dosing tanks at the Schenectady, N. Y., treatment plant are of this continuous-flow type. Since this plant has no regularly constructed means of flow determination, it should be valuable to others facing similar situations to review the methods used in gauging the flow through the Schenectady plant by calibration of the dosing tanks.

The Schenectady Gauging Problem.—The Schenectady plant consists of a bar rack, nine Imhoff tanks, divided into a full battery of six tanks and a half-battery of three tanks, three dosing tanks and three acres of tributary trickling filters, together with the necessary sludge bed area. Theoretically, each dosing tank handles the effluent from three Imhoffs; practically, this is true for one dosing tank, while the other two are installed at the battery of six tanks and take effluent from a common receiving basin.

Prior to 1920, but two siphons were constructed, each being a small chamber approximately 15 ft. long by 9 ft. 6 in. wide by 5 ft. 6 in. deep and fitted with a 30-in. Miller siphon. When the siphons discharged, the sewage in the effluent channels of the tanks was drawn down as the channels acted as continuations of the dosing tanks. Trouble was encountered as a result of the excessive amounts of sewage being discharged under the medium heads of the siphons and as a result of the rush of sewage under the siphon bells and the consequent breaking of the siphon seals.

In 1919, Metcalf & Eddy, then consulting engineers to the treatment works, designed enlarged dosing tanks with the old siphon chambers as portions of the new units and recommended the installation of the third dosing tank now in service. The recommended construction was carried out in 1921. The sketches, Fig. 1 and Fig. 2, show the details of construction; the photographs show one of the dosing tanks in operation. As now constituted, each dosing chamber consists of an effluent channel 30 ft. long and 5 ft. 10 in. wide, separated from the dosing tank proper by a concrete wall surmounted by a steel weir over which the tank effluent cascades into the siphon chamber. The unusually large area of the dosing tanks at the high discharge levels and the small area at the low levels make the tanks approximate the tapered tank in principle. Tapering is produced by a combination of sloping floors and vertical steps. Metcalf & Eddy suggested that the design of the tanks might prove to be over-generous in

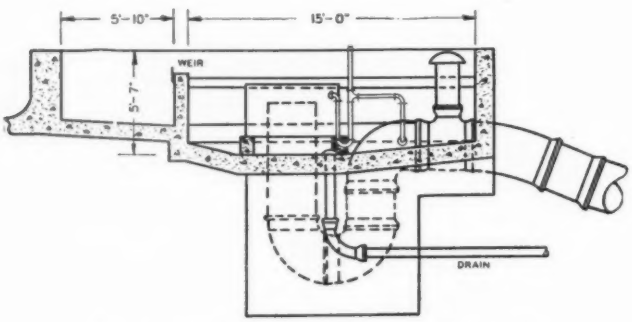


Fig. 1—Sectional Elevation of Dosing Tank

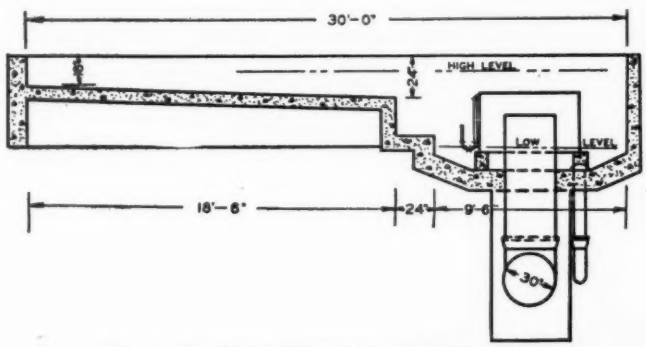


Fig. 2—Sectional Elevation of Dosing Tank

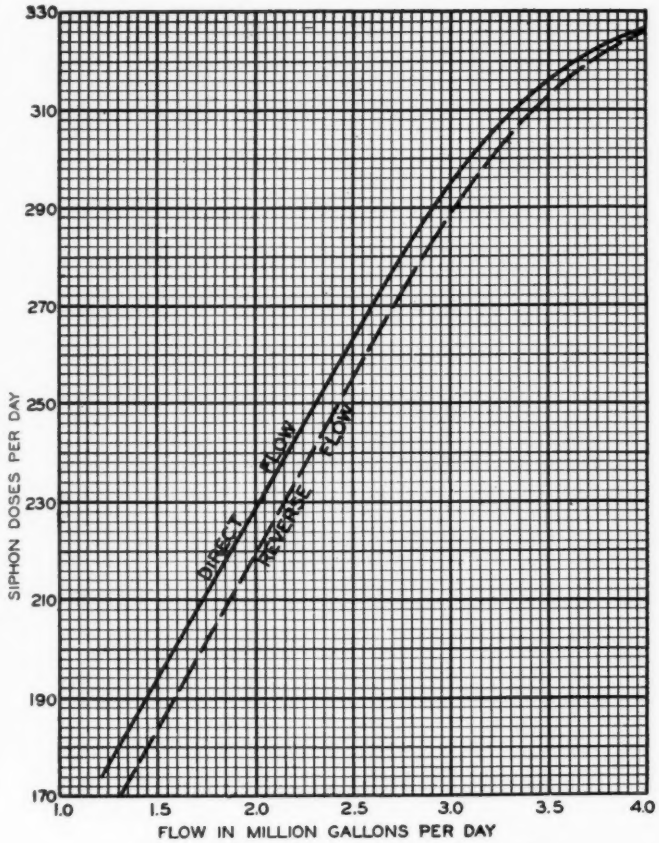


Fig. 3—Flow Curves—Dosing Tank "C"

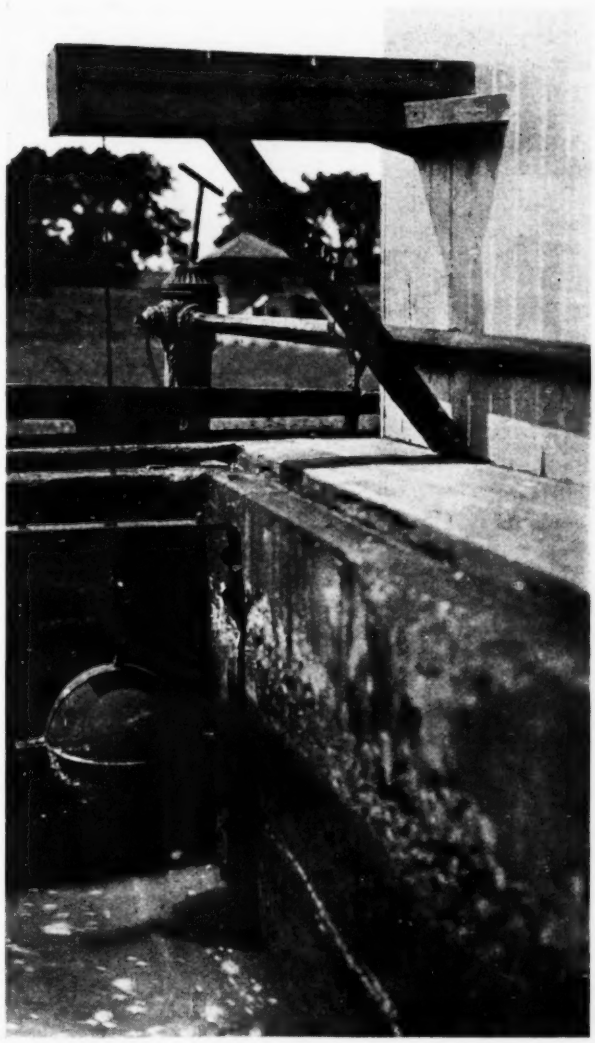
size and that changes could be made as found desirable by filling in with concrete or brick masonry. No changes have been made.

When the new dosing tanks were installed, it was felt that the 30-ft. weirs offered excellent opportunity for the flow measurements always needed at the works. Venturi meters were considered but were not installed because of the cost and, primarily, because the needed loss of head could not be spared. It was estimated that the dosing tank weirs would discharge 9 m.g.d. into the siphons with depths of flow over the crests of about 0.13 ft. Special liquid level gauges were purchased and installed in the receiving channels at the greatest possible distance from the weirs. The gauges were designed for 10-in. charts having a depth range of from 0 to 0.2 ft. Due to difficulty with false pressures on the rubber diaphragms of the type of gauge purchased, to the slight variation in depth on the weirs that occurred and to the inability of obtaining uniform head over the crests throughout the full 30 ft. of length because of the off-center point of effluent entrance into the receiving chambers, the weir scheme of flow measurement was abandoned.

Calibration of the Dosing Tanks.—The only other possible method of flow measurement remained that of calibrating the dosing tanks and preparing practical flow curves for each tank. Over a period of several months, accurate level readings were taken of the discharge and "sniff" levels of each siphon, under all possible conditions of flow quantity and direction of flow through the Imhoff tanks. The elevations were averaged and the capacity of the dosing chambers between discharge and "sniff" levels was computed. The tanks were found to hold approximately 5,700 gal. in working depths. For a period of approximately six months, stop-watch timings were made of the fill periods and complete dosing cycle intervals of each siphon and the accumulated data were recorded. Observations were made of every siphon cycle during the complete 24 hours of several days, the observers moving from dosing tank to dosing tank. Siphon recordings were made under all possible conditions of flow and under conditions of direct and reverse flow in the Imhoff tanks. Distinct variations in siphon operation was noted when flow was reversed through the tanks.

Having obtained the dosing characteristics of the siphons, the task of preparing flow curves remained. It was evident that any practical flow curves must be plotted to give the rate of flow through the dosing tanks for any observed number of siphon doses per day. Having given such a curve, the installation of a dosing counter in each siphon would supply all the information needed for the determination of the flow treated by the plant from day to day. Having given the capacity of each dosing from discharge to "sniff" level and the stop-watch reading of the time consumed in the fill period, the rate of flow into the tank per minute and per day was easily obtained. Again, from the stop-watch timing of the complete dosing cycle of the siphon, the number of doses per day which this would represent was easily computed.

These two correlated quantities were computed for each one of the several hundred observations made during the months of timings. The number of doses per day was then plotted against the rate of flow in each



Weighted Float, Chain and Pulley Box of Dosing Tank Counter

case and points on a flow-doses curve were obtained, in sufficient range to locate the curves. Several points outside the predominating tendencies of the curves were discarded and smooth curves drawn as weighted balances of the points used. Figure 3 illustrates the direct and reverse flow curves obtained for one of the Schenectady dosing tanks.

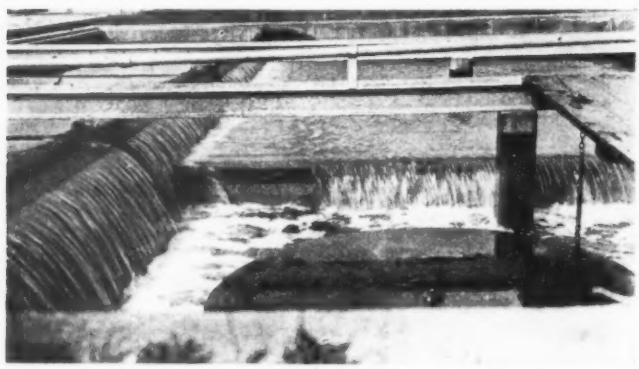
The following sample computation will serve to explain the method of point location used in obtaining the flow curves.

Assume, a tank capacity of 5,000 gal., a dosing cycle of five minutes and a filled period of 2½ minutes: 1,440, the number of minutes in a day, divided by 5, the minutes for cycle period, gives $1,440 \div 5 = 288$ doses per day. Now, 5,000 gal., the capacity of the tank, divided by 2.5, the minutes for fill, gives $5,000 \div 2.5 = 2,000$ gal. per minute, or 2,880,000 gal. per day. The abscissa and ordinate of the point representing this cycle and fill timing is thus obtained.

Counting Siphon Doses.—Having prepared the flow curves, there remained the necessity of installing dosing counters in each siphon chamber. The writer experimented with many types of manufactured counters and with a few home-made assemblies. Types varied from a small trip counter mounted on a disc of cork floating in the siphon chamber and fastened by a light chain so that it hung suspended and tripped the counter by its own weight at the low level of the siphon, to more complicated outfits. Two types of diving bell counters were tried. Such a counter works on the pressure principle, the rise of sewage in the dosing chamber submerging the bell and exerting a pressure through a connecting tubing to a flexible diaphragm which trips a counter by its movement. Another device tried was a heavy copper float, with projecting ears running in vertical guides, connected by chain to the arm of a simple trip counter.

Operating difficulties have varied from freezing and sticking of the counters in the winter to the clogging of the pressure piping of the diving bell type counter assemblies with grease curd deposited by the sewage. The housing of the counters out of the weather in a wooden structure and the connection of the floats to the counters by pulley systems solved the freezing troubles. The installation of the diving bells in stilling chambers, with upper ends well above the siphon high level line and the bottoms below the low water marks, solved the grease clogging with some success. At the present time, the siphon doses are being recorded by means of two counters of the float type and one of the diving bell type. Both types are working efficiently.

Routine procedure at Schenectady involves the daily reading and recording of the figures on the counters each morning at the same hour. Application of the day's doses for each siphon to the proper curve gives the flow through the unit. While it is felt that the curves are far from accurate, they, nevertheless, provide an easy, practical means of flow gauging where no other method is available. Numerous instantaneous dosing cycle and filling period timings have been taken since the curves were prepared and the computed ordinates and abscissas have been plotted. To a satisfactory degree, the curves have shown themselves to be trustworthy.



Dosing Tank, Schenectady, N. Y., Showing Tank Effluent Cascading Over Weir and Down the Chamber

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Results of Plankton Studies in Illinois River

The Illinois River, heavily polluted by the sewage and stockyard waste from Chicago, was used by the U. S. Public Health Service for a study of the effect of microscopic organisms on Nature's methods of purification of streams and a report (Public Health Bulletin No. 198) dealing with this particular study has recently been published.

Approximately 1,000 weekly samples, collected at every season, and including all sections of the river (which is nearly 300 miles long), were analyzed and studied. Particular information was sought relative to the abundance of such organisms as thrive in sewage-polluted water, and their gradual replacement downstream by organisms known to require water of a better grade. The gradual purification of the stream was thus expressed in terms of the prevalent kinds of microscopic organisms, both plants and animals, and collectively known as Plankton. The relative abundance of microscopic green plants was a matter of interest, inasmuch as these plants help to purify the water by the oxygen they give off, similar to the action of the common "fish moss" in goldfish bowls.

Very briefly summarized, the results of this study indicate the following changes as the water progresses:

1. The swift upper portion of the river, heavily polluted but thoroughly mixed, is well seeded at the start with microscopic organisms from the tributary Des Plaines River and from Lake Michigan.

2. Gradually decreasing velocity distributes the suspended matter over a very large total area of bottom downstream, facilitating biological action.

3. The grayish water becomes clear, and loses its odor of sewage 70 or 80 miles downstream from the Chicago Drainage Canal outlet.

4. Correlated changes in the plankton content are: (a) Decrease of pollutional organisms formerly predominant, (b) increase of organisms of the cleaner-water kinds, these becoming predominant, and maintaining this status thereafter, and (c) increase in relative abundance of microscopic green plants.

5. In all sections of the river, and at all seasons, the microscopic green plants were decidedly more abundant, volume for volume, than were the microscopic animals.

6. Malodorous bottom sediments from the polluted upper Illinois contained very large numbers of "sludge worms," and no gill-bearing insect larvae, whereas sediments from the lower portions of this stream were free of odor, contained very few worms, and showed a variety of gill-breathing insect larvae.

A suitable background for the above study is furnished by eleven abstracts of similar studies made on other streams and on the Illinois River by various investigators. The large amount of data relative to the Illinois River is summarized in 54 tables and 18 graphs.

SYMPOSIUM OF PRACTICE

HOW PAYMENT IS SECURED FOR WATER USED IN CONSTRUCTION WORK

Mobile, Ala.

In the case of a party wanting to build a house we first request him to secure a building permit from our building inspector. He then brings this permit to our office and from this permit we make our charge for water, charging 12 ct. per 1,000 for the amount of bricks to be laid and 1 ct. per square yard for the plastering. In case of sidewalks or concrete work of any kind we charge 4 ct. per cubic yard. We require the payment of the charge at the time that the application for the water is made. In case of street work where concrete roads or sidewalks are to be laid, we get the measurements from our city engineer and we charge at the rate of 4 ct. per cubic yard and insist on pavement being made in advance. We have had no trouble in this deparment with this kind of business.—H. Charest, Superintendent Water Works, Mobile, Ala.

Henderson, N. C.

The only way to obtain payment for water used in construction work or for water used for any other purpose is to meter it and make a reasonable inspection of your meter at frequent intervals according to season and the nature of the work, and if possible always prevent any water from being drawn from a hydrant. We have on one or two occasions yielded to that request and have supplied water through a 2-in. meter from hydrants with a flexible connection which permitted the meter to set firmly on the sidewalk. We have used this method where road contractors wanted to keep concrete pavements wet for three weeks. To do this, however, requires almost daily inspection of the meter and its use. For small construction of buildings we set the meter after the initial start of the work.—J. H. Bridgers, Manager, Henderson Water Works.

Lexington, Ky.

We require payment on all water used in construction work of any kind. On street and sewer work if the contractor cannot arrange with some property owner who has water service for water, he is required to have installed at his expense a tap with meter. For flooding trenches we have a hydrant meter and used attached to fire hydrants. An employee of our company stays with this meter while in use; the contractor pays for water used and this man's time.—W. S. Cramer, Vice President, Lexington Water Co.

Norfolk, Va.

Before the building inspector of this city will grant a permit for the construction of any building, he requires the endorsement of the water department on the application, indicating that the proper application has been made and fee paid for the water connection. In this way we obtain the contractor's name and address. When the contractor reports the building completed the water meter is read, and he is billed for all water used to that date. If the bill is not paid within the year in which it is incurred, his name is put on a "black list," alphabetically arranged, and we refuse to endorse any application for him thereafter until all the back bills are paid. If he fails to notify us when the building is completed, we charge him for all water recorded up to the date of the first application by a tenant for the water service. In the case of water used for road construction, we charge the contractor either by meter measurement or yardage.—A. E. Price, Assistant Superintendent, Division of Water Supply, Norfolk, Va.

Western New York Water Co.

We meter all water used for construction purposes and require the contractor to make a deposit covering the value of the meter and the estimated quantity of water necessary for the particular job. Meters are set on hydrants, existing taps or special taps made for the job, as the circumstances may warrant. The contractor pays the cost of tapping (if necessary), setting and removing meters and water used is billed at regular schedule rates. After the meter is returned in good condition and all charges are paid, the deposit is refunded. It is essential to check meters frequently, particularly on large jobs, to avoid loss of registration due to careless handling, introduction of foreign matter in couplings, etc.—H. S. Dewey, Manager, Western New York Water Co., Buffalo, N. Y.

Louisville, Ky.

The practice of the Louisville Water Co. is to install a meter on construction work and sell the water by meter measurement at prevailing rates, rendering monthly bills. While this is the practice, it is known to be true that many contractors secure water from fire hydrants without the consent of the water department. The obtaining of water in this latter way is difficult to control, but the rule is as stated.—John Chambers, Chief Engineer and Superintendent, Louisville Water Co.

Philadelphia Suburban Water Co.

The Philadelphia Suburban Water Co. generally charges for water used in construction work on the unit basis. For highway pavements, or sidewalk construction, charge is made per square yard of finished surface, the charge varying according to the depth of pavement. For building construction the charge is based on the size and character of the building; charges for other construction are made on a similar basis.—C. E. Davis, Manager, Philadelphia Suburban Water Co., Bryn Mawr, Pa.

Passaic Valley Water Commission

The first step is to secure co-operation between the city departments and the water department. An effort should be made to have the city council pass an ordinance making it a misdemeanor, punishable by fine, for any unauthorized person to operate the hydrants of the water system. This being done, all contractors or builders who wish to use water for construction purposes, must come to the water department to get a permit for the use of water. They should be required to furnish a plan showing the building or the job to be done, and the amount of water which will be required for the work can be figured out from the plan. The contractor is then asked to put up a deposit covering the full cost of the water which it is estimated will be used. The water department can then place a valve on the hydrant which the contractor wishes to use, and he can draw water at will without operating the hydrant. During winter weather, of course, it is necessary to shut down the hydrant at night to prevent freezing, and this cost should be charged to the contractor. In our system we usually find that the contractor prefers to pay a flat rate for the use of water through a valve attached to the hydrant, as stated above, as in placing a meter the installation cost makes it run higher than if payment is made by flat rate.—A. T. Cook, General Superintendent, Passaic Valley Water Commission, Paterson, N. J.

San Francisco, Calif.

Our rules require that all services be metered, but frequently we find contractors and others using from open hydrants. We therefore apply the following flat rate charge: Service through fire hydrants and other unmetered services—(The contractor to obtain permission for use of fire hydrants from the Board of Fire Commissioners):

For water required for concrete, brick, rubble or other masonry construction, per cubic yard 12.0 ct. For water required for each barrel of cement or lime for any other purpose 12.0 ct. For water required for grading streets, including water used by steam roller, per 100 sq. ft. 9.6 ct. For water required for settling earth fills, grading and back filling trenches, including water required by steam roller, per cubic yard of earth 4.8 ct. For water required for small steam or gas engines used on construction work per 8 hour day 48.0 ct.—N. A. Eckart, general manager, Water Sales Division, San Francisco Water Department.

Springfield, O.

We endeavor to have all water used for construction purposes measured by meters. As the matter works out, however, meters have not been applied on the majority of our smaller construction jobs. In such cases, the contractor or owner is to pay for water used in masonry, plastering and other units according to flat rate schedule used by the department for many years. These charges are made to the following units: Brick work, per 1,000 brick; stone masonry, per perch; Plastering, per 100 sq. yd.; cement work, per sq. ft.; curb and gutter, per lin. ft.; paving, per sq. yd.; cement block, per 100 blocks.—C. T. Bryant, Superintendent, Springfield Water Works.

Raton, N. Mex.

I have made some study of this question, but so far I have failed to see wherein the water department should concern itself as to how water is used after a service has once been intsalled—whether it be for construction or for baths or lawns or gardens is immaterial. Our rule is that when an applicant wants a service installed we install it and ask no questions as to how the water is to be used. And a charge is assessed from the date the water is introduced into the new service, irrespective of the purpose for which it is used. Do light utilities furnish power and lights free in construction work? I do not know what the practice is with them, but even if they do, personally, I fail to see the justification for it.—G. C. Culberson, Manager, City Water Works of Raton.

Erie, Pa.

Our charges for water used for building purposes are as follows:

Concrete, 3 ct. per cu. yd.; Stone, 10 ct. per cord; Brick, 4 ct. per 1000; Cement Block, 6¼ ct. per 100; Plaster, 12c per sq. yd.; Steam shovel, 10 ct. per 100 cu. yd. Each builder must make application for this service and give the quantities of material to be used, payment for which is usually made in advance. Whenever this payment is not made in advance the charge is held against the property and must be paid before the regular service is granted. We do not have a metered domestic supply and therefore payment for water used in construction work must be based on the flat rate schedule as given above.—J. S. Dunwoody, Superintendent of Water Works, Erie, Pa.

Danville, Va.

For building construction water taps are made when construction work is started, and meter installed, and all water consumed is charged for at regular rate schedule. In the case of street construction, water is taken from street fire hydrants and meters installed, and water consumed is billed accordingly.—J. T. Hall, Commercial Manager, City Water, Gas and Electric Department, Danville, Va.

Des Moines, Ia.

In this city water is furnished for construction work through meters.—Charles S. Denman, General Manager, Des Moines, Water Works.

Pittsburgh, Pa.

The Bureau of Water charges the following rates for water used for building purposes: Stone, per perch, 5 ct.; brick, per 1,000, 10 ct.; plaster, per 100 sq. yd., 50 ct.; cement flooring, per 100 sq. ft., 12 ct.; concrete, per cu. yd., 5 ct.

Richmond, Ind.

Water used in construction work is generally furnished through meters.—H. A. Dill, Superintendent, Richmond Water Works Corporation.

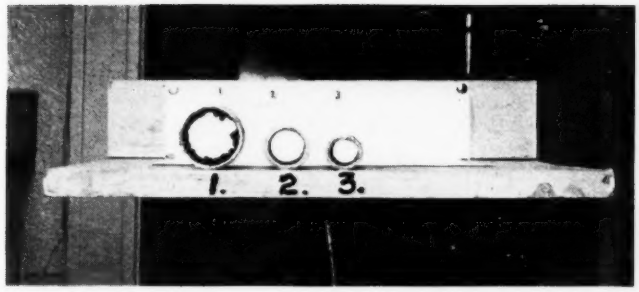
Oklahoma City, Okla.

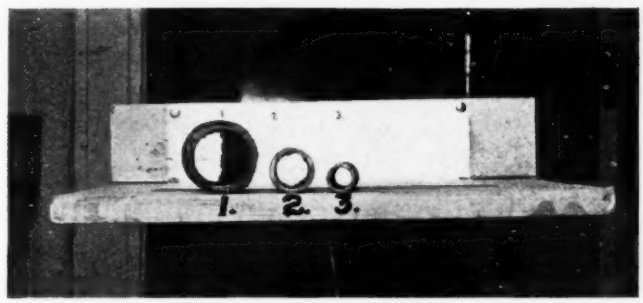
We either make a separate tap and set a meter or allow the contractor to take water from the nearest fire hydrant, same having a meter set at the fire hydrant. All water for construction work is metered and paid for at the regular rates.—C. E. Bretz, Superintendent and Engineer, Oklahoma City Water Department.

CORROSION REDUCTION WITH LIME TREATMENT

By EDWARD S. HOPKINS

Principal Sanitary Chemist, Montebello Filters, Bureau of Water Supply, Baltimore, Md.





THE Gunpowder River used as the source of supply for Baltimore, Md., is a moderately soft, typical eastern seaboard water. Such a water is naturally corrosive, necessitationg corrective treatment. Continuing the policy inaugurated by Baylis* in 1922, lime has been added to the filtered water for this purpose. With changing buffer characteristics of the water in the past few years, it has been possible to maintain complete absorption of carbon di-oxide at a pH value of 8.0 instead of the initial higher 8.3 value. The relationship of carbon di-oxide to pH was checked weekly by the calcium carbonate test. This procedure has reduced the lime dosage from about 0.45 g.p.g. in 1922 to 0.30 g.p.g. in 1930 as the average daily application.

The control of this chemical has been very satisfactorily maintained using a Leeds & Northrup recording potentiometer with a tungsten electrode. The charts utilized on this device serve as a permanent H ion concentration record of the water as delivered to the city. Careful supervision of the curve trends enables the plant operators to maintain pH values within narrow limits of error.

Cost of Lime Treatment.—It is of interest to note that lime application cost 16 ct. per million gallons of water pumped in 1930 and 32 ct. in 1922. Such a large saving is attributed to a decrease in the cost of lime in recent years, and also to a reduction in the alum used for coagulation. In 1922 an average of 1.04 g.p.g. of alum was necessary and in 1930 but 0.56 g.p.g.

Benefits of Treatment.—The benefits obtained by such treatment amply justify its cost. Figure 1 gives a comprehensive picture of the H ion concentration of the water as supplied to the city. It shows that sufficient alkalinity has been constantly maintained to eliminate cold water corrosion. This is confirmed by daily iron analyses. The water leaving the plant contains between 0.03 and 0.10 parts per million Fe. Tests from a tap on the distribution system, after passage through an open balancing reservoir, are in close agreement with this value, usually about 0.02 parts per million higher.

The distribution system is in three phases; the low service area is directly supplied from the plant; the middle service area is supplied from open balancing reservoirs into which water is pumped from the low service; and the high service area is supplied by a second group of open reservoirs obtaining water from the middle service. Hydrogen ion concentration studies of water from the reservoirs and from corresponding tap sources, gave curves in very close agreement with each other. This is shown for all sections of the city in Fig. 2, tap samples only being plotted. It is to be noted that these values are comparable for all areas within practical limits, and that excessive reduction of alkalinity does not occur as the result of passage through the balancing reservoirs.

The practical effects of this treatment which is also supported by the data in the curves, is given in the illustrations at the head of this column. The pipe shown in the top cut is from the low service area. Sample No. 1 had been in service about 20 years; No. 2 about 5 years and No. 3 about 4 years. These specimens were located about 8 miles as average distance from the plant and in different parts of the city. The pipe in the lower cut is from the middle service area. Sample No. 1 had been in service about 40 years; No. 2 about 4 years and No. 3 about 5 years. They were located about 3 miles average distance from the secondary reservoirs in each case.

The photographs tell a very clear story. Previous

*Baylis, John R., Eng. Cont., 57:51 (1922).

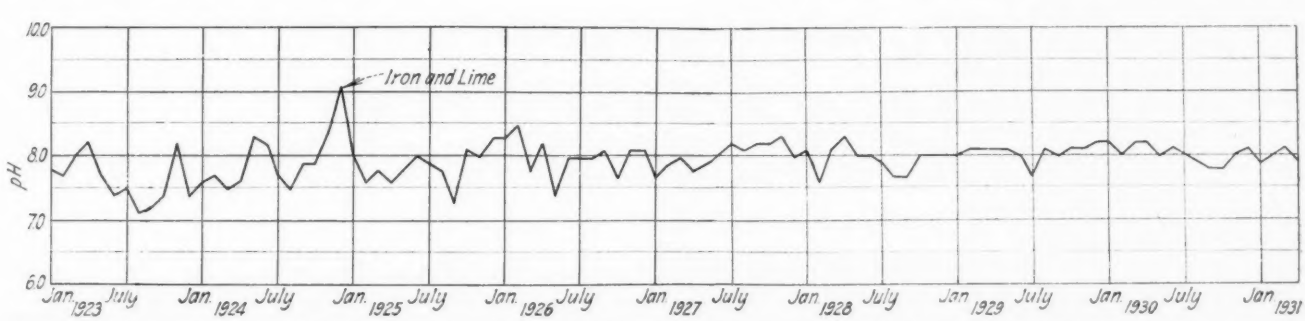


Fig. 1—Hydrogen Ion Concentration of Water as Delivered to City. Monthly Average of Bi-Hourly Samples

to the treatment of the water with lime, excessive pitting with considerable deposit occurred. This was particularly true of the pipe 40 years old. That in service for 20 years was pitted with many tubercules, but no matted deposits. After treatment, only the "egg shell" thickness of protective coating is found. This is true

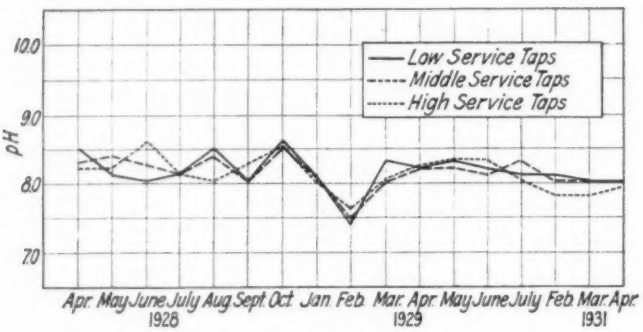


Fig. 2—Hydrogen Ion Concentration of Water in Mains

for all sizes of pipe inspected from ¾ in. to 12 in. in diameter.

That corrosion is prevented by deposited calcium carbonate is shown by the analysis in the following table:

RATIO OF Fe TO Ca IN SCALE

Service	Specimen No.	Years in Service	Ratio	Remarks
Low	1	20	1:.037	Excessive pitting
Low	2	5	1:.146	"Egg shell" scale only
Low	3	4	1:.165	"Egg shell" scale only
Middle	1	40	1:.061	Pitting and rust deposit
Middle	2	4	1:.121	Slight corrosion—"egg shell" coating
Middle	3	5	1:.119	"Egg shell" scale only

Conclusions.—Absorption of carbon di-oxide by the use of lime is practical, cheap, and easily controlled. This procedure assures the elimination of "red water" troubles in water. Excessive amounts of lime will tend to clog smaller pipes and must be avoided. This may be prevented by careful supervision or automatic regulation. As shown by the illustrations, this treatment will adequately protect service pipe, thereby saving in a few years, sums many times in excess of its cost.

Appreciation is acknowledged of the assistance given by Mr. D. H. Goldsborough of the Distribution Division for his many courtesies, and for securing the specimens of pipe used in the investigations.

Acknowledgment.—The above is a prepared discussion presented May 28 at the annual convention of the American Water Works Association.

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DEATH FROM DRINKING IMPURE WATER HELD ACCIDENT.—The Indiana Appellate Court, in the case of the State et al. vs. Smith, 125 N.E. 146, handed down a decision on March 4 holding that a death resulting from drinking impure water was an accident and thus came under the workmen's compensation act. It seems that an employee of the state highway commission became ill with gastroenteritis as a result of drinking some polluted water which was furnished to him while at work. Later pericarditis developed and death ensued. In a proceeding by the employee's widow under the workmen's compensation act, the appellate court affirmed the industrial board's award of compensation, holding that the death was one by accident within the meaning of the compensation law.

COMING CONVENTIONS

New England Water Works Association

Good progress is being made with the plans for the 51st annual convention of the New England Water Works Association which will be held September 29 to October 2 at the Hotel Statler, Boston, Mass. An excellent program of papers is being prepared and there is every indication that there will be a large attendance of members and guests. The nominating committee of the association has reported the following list of nominations for officers to be elected for the ensuing year:

For President—George C. Brehm, engineer with Metropolitan District Commission, 20 Somerset St., Boston.

For Vice President—E. Sherman Chase, Metcalf & Eddy, Engineers, Statler Building, Boston.

For Directors—Harry U. Fuller, engineer, Portland Water District, 16 Casco St., Portland, Me.; Frank E. Waterman, commissioner of public works, Providence, R. I.

For Treasurer—Albert L. Sawyer.

Announcement has been made that the entertainment committee and the exhibit committee of the Water Works Manufacturers Association for the convention will be as follows: Entertainment Committee—Burt B. Hodgman, chairman, National Water Main Cleaning Co.; John S. Warde, Rensselaer Valve Co.; Samuel Harrison, Worthington Pump & Machy. Corp.; H. W. Jacobs, Cement Lined Pipe Co. Exhibit Committee—Guy C. Northrop, chairman, Hydraulic Development Corp.; J. Herman Smith, Hersey Manufacturing Co.; Ralph L. Kelly, Union Water Meter Co.; M. C. Allan, Builders Iron Foundry.

Rocky Mountain Section, A. W. W. A.

The program committee for the 5th annual convention, which will be held October 21-23 at Denver, Colo., spent June 29 in preparing a real program of interest and value to every water works man. Special efforts are being made to make this year's meeting the biggest and best ever held by this section. In connection with the convention there will be a short school for water works operators. It is expected to have the cooperation of the Municipal League and the State Board of Health of Colorado, The Mountain States Inspection Bureau and the Denver Water Department, in this enterprise. Dana E. Kepner, 226 Continental Oil Bldg., Denver, Colo., is secretary-treasurer.

INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS.—The annual conference of this association (formerly the International Association of Street Sanitation Officials), will be held September 24, 25 and 26, at the Pennsylvania Hotel, New York, N. Y.

AMERICAN ASSOCIATION OF ENGINEERS.—The 1931 convention will be held September 28, 29 and 30, at Huntington, W. Va. M. E. McIver, secretary, 8 South Michigan Ave., Chicago, Ill.

CENTRAL STATES SECTION, A. W. W. A.—Annual convention, Starrett's Netherland-Plaza Hotel, Cincinnati, O., October 8-9. B. J. Lechner, secretary-treasurer, Commissioners of Water Works, Erie, Pa., is secretary-treasurer of the section.

SOUTHWEST WATER WORKS ASSOCIATION.—Annual convention, Jung Hotel, New Orleans, La., October 19-22. Lewis A. Quigley, superintendent, water works, Fort Worth, Tex., is secretary-treasurer.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

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HOW BACTERIA ARE KILLED BY DISINFECTANTS

THE almost universal use of disinfectants to aid in the purification of drinking water should make us interested in the manner in which the disinfectant kills bacteria or other microscopic organisms. Now that the chemical characteristics of our most widely used disinfectant (chlorine) is being altered in a number of water supplies by the addition of ammonia to the water, it seems that we should give more consideration to the chemistry of disinfection so as to more thoroughly understand its mechanism. The purpose of this article is to try to stimulate interest in the subject with the hope that some of our research students will take it up and conduct tests that will give us more specific data. About all we know now is if there is a certain excess of chlorine in the water for a certain time nearly all the bacteria will be killed. Now it is nothing uncommon for us to make use of processes where we do not understand all the reactions that take place and all the factors that influence the reactions, yet it is evident to work to the greatest advantage it is better to know as much as possible about the influencing factors.

There Are Many Disinfectants and Narcotics.—It has been known for many years that there are a number of compounds that will kill bacteria. It also has been known for years that certain compounds will produce narcosis in the higher animals as well as compounds that will produce death. All are aware that certain drugs will make the body or the part of the body affected by the anesthetic insensible to pain. After a certain time the effect of the drug passes away, apparently leaving no ill effect as a result of its use. With disinfectants, it is different, for the life cells do not return to normal. No attempt will be made to name all disinfectants, and only a few of the ones more commonly used will be mentioned, such as silver nitrate, mercuric chloride, chloroform, phenol, potassium permanganate, copper sulfate. hydrogen peroxide, ozone, chlorine, chloramine, iodine, and ultra violet light. Compounds like hydrogen peroxide, ozone, chlorine, and chloramine are known as oxidizing agents. That is, their disinfecting power is thought to be due to the liberation of oxygen in a very active state. Chlorine, chloramine, ultra violet light, and ozone are the only substances used to any material extent to disinfect potable water. Potassium permanganate has been used in a few instances to reduce tastes in water, but it would not be used if sterilization was the only consideration.

Narcotics, of course, are never added to water supplies. They are used as medicines, and in a few instances by individuals who have become addicted to their use. It probably has not occurred to many that the effect of anesthetics or narcotics may be largely the same as disinfectants, except the anesthetic or narcotic soon passes off and there is a return to normal conditions, whereas in the case of disinfectants the change produced in the cells is a permanent one and there is no return to natural conditions.

Narcotics and Disinfectants Produce a Coagulation of the Cell Colloids.—Bancroft and Richter[1] made a very extensive review of the literature on the chemistry of anesthetics and disinfectants, and part of this article is more a digest of these articles than the presentation of original material. They show that practically all the data of the various workers can be explained on the basis that there is a coagulation of the colloids within the cells of the organisms. In most instances the narcotic or disinfectant diffuses into the cell and is absorbed by the colloids. A large portion of the colloids in most living cells are in a dispersed state under natural conditions, and the absorption of certain compounds by these colloids produces coagulation.

Colloidal Particles.— Every one familiar with water treatment should know what is meant by coagulation. It is the assembling into masses of numerous minute solid particles. The average particle of aluminum hydroxide coagulation readily visible to the eye is made up from many thousand very minute particles of the compound which have coalesced. There has been so much in the chemical and water purification literature on colloids that most of us understand what is meant when reference is made to a colloidal particle. It is a solid mass of molecules of extremely small size united in crystalline and perhaps sometimes in amorphous form. For the crystalline particles, some are of the opinion that all solid particles less than 0.001 millimeter in diameter should be classified as colloidal.

There is no well defined line where we should say if the particle is smaller it is colloidal. A particle 0.001 millimeter in diameter is readily observed with a high power microscope, yet many, if not the majority of colloidal particles cannot be observed with the most powerful microscope. This is largely the case with colloids existing in the fluid within living cells. Most bacteria, when observed alive under the microscope, look as though they are hollow cells, though it is evident that the fluid within the cells is filled with colloids. It may be possible for hundreds or even thousands of colloidal particles to exist within the cell of one bacteria.

Function of the Cell Colloids.—The colloids within the living cell help to support life and cause the cell to grow and divide. The growth, when conditions are favorable, may be quite rapid. The bacteriologist knows

that one bacteria may produce millions of bacteria within 24 hours when placed in favorable environments. For one bacteria to produce one million bacteria within 24 hours, the cells must divide at the rate of about one division every 72 minutes. This is assuming that there would be two cells at the end of 72 minutes, 4 at the end of 144 minutes, 8 at the end of 216 minutes, and so on in a geometric ratio.

The various soluble compounds in the solution surrounding the cells diffuse through the cell walls of the bacteria into the solution within the bacteria. Such compounds as are used by the bacteria go into various combinations, some of them being converted into the compounds that form the colloids, and new colloidal particles are formed. These particles absorb ions from the solution which gives them an electrical charge that keeps them in a dispersed state. It is evident that every cell must have a porous wall, with the pores of such size that soluble compounds can diffuse within but the colloidal particles cannot diffuse out. It may not be necessary for the entire cell wall to be porous, yet it probably is with bacteria.

Chemical Balance in Living Cells Probably Very Delicate.—A very delicate chemical balance probably exists within living cells, and it is evident that the presence of certain chemical elements may play havoc with the contents of the cell. The literature, as previously stated, points quite strongly to the fact that all narcotics and disinfectants are absorbed by the cell colloids and cause a coagulation of the particles. This being the case, why does one kill and the other does not? Where the coagulation is due to the absorption of a narcotic the cell protoplasm returns to normal after the narcotic passes away, with apparently no injury to the cell. Disinfectants coagulate the cell colloids the same as narcotics, but upon removal of the compound from solution the cell colloids do not return to normal. An irreversible coagulation has been produced and death results.

A direct narcotic diffuses through the cell walls of living organisms and is absorbed by the colloids to which it is most attracted. Bancroft and Richter believe the first effect may be to displace material that was already on the surface of the colloids. The displacement of this normal material increases its effective concentration in the water phase. This increase in concentration, in accordance with the law of mass action, will speed up chemical reactions which the substance may be undergoing. These authors regard this as the stimulating effect on the chemical reaction of a cell by narcotics and toxic agents. The greatest stimulating effect will be on those reactions that show a small tendency to be reversible, such as oxidations. The continued accumulation of the narcotic upon the cell wall reaches a point where the effect of the narcotic and the electrolytes of the cell produce coagulation. When the agent that causes the coagulation is removed, the colloids may again become peptized, and resume their natural function. If the colloid has become so drastically altered that peptization does not take place upon removal of the agents that caused coagulation, or if the agent is irreversibly absorbed, death usually takes place.

Three Effects Produced by Narcotics and Disinfectants.—Bancroft and Richter state that always two effects, narcosis and toxic action, and nearly always a third, stimulation, can be obtained from one and the same compound. It is probable that the initial stimulation is always present, but if the increase in the effective concentration by displacement is negligible the stimulation may not be very great. These authors state that with pathogenic bacteria and protozoa the three stages, stimulation, narcosis, and toxic action are frequently observed. Very low concentrations of a disinfectant sometimes stimulates the organisms which we wish to kill. The writer wonders if this offers an explanation for some of the bacterial increases in water distribution systems in the zone where the residual chlorine has practically disappeared from the water. Bacterial aftergrowths have been observed in a number of water supplies.

Many Compounds Produce Coagulation of the Cell Colloids.—Bancroft and Richter experimented with yeast cells, and found that microphotographs of the normal cells appeared optically empty due to the fact that light from the micella was too faint to make an impression on the plate, but when the culture was treated with a solution of mercuric chloride the material within the cells coagulated and showed on the microphotograph plates. To test the effect of oxidizing agents these authors used hydrogen peroxide, a fairly mild oxidizing agent. This produced a very extensive coagulation of the colloids within the yeast cells, showing that the sterilizing effect is a coagulation similar to that produced with mercuric chloride. Yatren, and acidic substances, was then tried and showed the same coagulating effect. Aliphatic compounds such as chloroform and carbon tetrachloride, and aromatic phenols produced the same effect. In the case of chloroform it was easy to reverse the coagulation by merely washing the organisms with fresh media. It is difficult to draw a sharp distinction between a disinfectant and an antiseptic, for the coagulation may be reversible in the preliminary stages of disinfectants and irreversible if high concentrations of an antiseptic are used.

Ultraviolet Light Produces Coagulation.—Clark[2] investigated the action of ultraviolet light. In sols that had a negative charge, the loss of electrons by light action would leave neutral or positive particles, the mutual action of the positive and negative colloid would tend to coagulate the sol. A positive sol, when exposed to ultraviolet light, loses electrons and becomes more positive, and peptizes to a greater degree. Gibbs[3] exposed spirogyra to the rays from a mercury vapor arc, and found that the variations produced in the viscosity were characteristic for coagulating protoplasm. Addoms[4] examined root hairs with an ultramicroscope to detect the effect of toxic substances on the structure of the protoplasm. In 0.1 N concentrations, salts of potassium, sodium, calcium, magnesium, zinc, and aluminum produced characteristic alteration of the colloid structure of the cell. The alteration was in the nature of a coagulation, and with some salts a flocculation of the protoplasm. Although actions are in most instances the effective agent, certain anions such as aluminates and cyanid seem to produce an effect. Addoms also shows that ultraviolet light will produce coagulation and flocculation of the cell protoplasm. He states that experimental evidence suggests, but does not prove, that only wave lengths shorter then 300 millimicrons are instrumental in producing these results.

When ultraviolet rays are passed through suspensions of bacteria only the rays that are absorbed are effective in killing bacteria. Bancroft and Richter conclude that the toxic action of the ultraviolet light is due to a coagulation of the protein colloids of the cell, which makes it in harmony with other types of disinfectants.

How Long Does It Take to Kill Bacteria?—If the observations of the various authors quoted are correct, and it seems to the writer that the theory of coagulation of the cell colloids is the most plausible one that has been offered, then we might wonder just how long it

takes to kill bacteria. There is evidence that the bacteria in water will not grow in the culture media ordinarily used in testing for bacteria after they have been exposed to chlorine for one minute if the residual chlorine is high. That is, the bacteria apparently are killed within a very short time, the adsorption of a fatal dose of the sterilizing agent being quite rapid. Are they actually dead within this time?

If the coagulating effect produced by toxic agents is the sole cause of death of living cells, then a bacterial cell is not dead if by some means the coagulated protoplasm can be peptized. The introduction of the bacteria into the usual culture media apparently does not produce peptization when chlorine has been used for the sterilizing agent, but this may not mean that the bacteria cannot be restored to life under certain conditions. Bancroft and Richter give the following:

"Since the death of organisms is due to irreversible coagulation the question of reversibility and the conditions which favor it are important. Normally in testing disinfectants the organisms are exposed to the agent and then placed in some medium to observe whether growth takes place or not. Indeed, this is a convenient but not very accurate method, for the peptizing agents of different substrates are quite different. For example, Liesegang mentions a case where the bacteria of bird cholera were exposed to 1:1,000 mercuric chloride solution for seven minutes; these organisms were then unable to develop on ordinary media. One would ordinarily conclude that they were dead. However, it is not the case for if they are placed in their natural environment, birds, they begin to develop after three hours. The conditions favoring peptization are much better in the animal body than in the laboratory media. Supfle gives a striking example of peptization of anthrax bio-colloids after treatment with mercuric chloride. The organisms after exposure are apparently dead when tested on ordinary media. Supfle mixed these organisms with a good grade of blood charcoal and cooled the mixture, to aid the adsorption. In this case the sublimate is adsorbed much stronger on the charcoal than on the bacteria so the material leaves the anthrax cells and is deposited on the charcoal. Upon removal of the charcoal, the organisms are found to be again normal and grow well on the ordinary media. In this way it was found that reversibility could be effected in organisms exposed to:

5 per cent sublimate after 11 days
3 per cent sublimate after 38 days
1 per cent sublimate after 40 days.

". . . In the light of colloidal chemistry the testing of disinfectants should be studied from the point of view of the reversibility of the coagulation produced by the disinfectant rather than the determination of growth, on relatively inert media, after exposure."

More Study Needed.—It seems that the above quotation should impress every water chemist and bacteriologist with the importance of more study along this line. The writer does not feel alarmed, and believes that most of the bacteria are killed with the disinfectants commonly used in water treatment. If chlorine kills most bacteria within one minute so that they will not revive by the customary culture media, it seems that this remarkable quick sterilizing effect should make us feel that an irreversible coagulation is produced when the chlorine remains in the water for several hours. The freedom from water-borne diseases where the water is properly sterilized gives added proof that the bacteria are actually killed. The data, however, are of such a nature as to throw doubt upon the supposedly very rapid sterilization of water with disinfectants now generally used.

It is believed that we should take the advice of Bancroft and Richter and study the reversibility of the coagulation produced by the disinfectants used in water treatment. It may be found that longer contact periods for the disinfectants are desirable. The water purification plant operators should take no chance on something that so vitally effects the health of a community. If it takes 4 to 6 hours to actually kill bacteria so that they cannot be brought back to life under any condition, this should be known so that such contact periods can be provided. The fact that it requires over 11 days to actually kill anthrax bacteria in a 5 per cent solution of mercuric chloride whereas tests with the usual culture media shows rapid sterilization, there is the possibility that the time required for sterilization is much longer than we have thought it to be.

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Estimating Size of Outdoor Swimming Pools

Certain arbitrary standards have been worked out to aid in estimating the size of an outdoor swimming pool. In a bulletin "Planning the Outdoor Swimming Pool," issued by the Engineering Extension Service of Iowa State College, Mr. Lindow J. Murphy gives the following: A study covering a number of swimming pools indicates that about 80 per cent of the bathers can generally be found in the area 4½ ft. deep or less. Managers of public pools recommended that at least 75 per cent of the area be made shallow enough for wading (4½ ft. deep or less) and the rest vary from 4½ to 9 ft. for swimming and diving.

Swimmers have been found to occupy from 20 to 50 sq. ft. of area each. The Joint Committee of the American Public Health Association and the Conference of State Sanitary Engineers has recommended that an average of 27 sq. ft. should be provided for each swimmer who may be expected to be present at the time of maximum load. Non-swimmers require much less area due to their lesser activity. An area of from 10 to 20 sq. ft. per bather should be provided in this portion of the pool.

Several state boards of health also require that there be at least 800 gal. of water for each person using the pool at one time. In a pool designed as indicated above there would be considerable excess over this amount. It is evident that a pool designed for a large proportion of swimmers would be relatively deep, hence it would contain a large volume of water per swimmer. Likewise a pool designed with a large wading area, being relatively shallow, would have a low water content.

It is also apparent from a study of many pools that the size of the city or district in which the pool is located, has an influence on the attendance at the pool. The smaller the community the larger the proportionate attendance at the pool. Pinel has stated that for cities under 30,000 inhabitants the maximum daily attendance has been found to be from 1/11 to 1/18 of the total population. The average is about 1/14. The maximum number of bathers that use the pool at any one time seems to average about 1/5 of the maximum daily attendance.

MANGANESE IN WATER— ITS OCCURRENCE AND REMOVAL

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MANGANESE, which is grouped with iron in chemical classifications, is a relatively infrequent component of water, and even when present is usually found in small amounts. It is more frequently found in ground water, but its occurrence in surface water has been reported also.

In water, manganese behaves somewhat like iron but it usually oxidizes more slowly and with the formation of the black hydrated oxide instead of the familiar red iron oxide. Usually its presence is due to the decomposition of organic matter in manganiferous soils and the resulting solution of the manganese in the humic and other soil acids as well as in carbonic and sulphuric acids.

In the stagnant bottom waters of certain deep reservoirs, a condition which favors the production of hydrogen sulphide and the bacteriological decomposition of sulphates, manganese is often present, usually in combination with iron.

Occurrence of Manganese.—In New Jersey in 1928 the Department of Health[1] found that the manganese content in 238 of the portable water supplies of that state ranged from 0.03 to 0.20 p.p.m.

Corson[2] found that out of 147 waters from wells, 60 had a manganese content of from 0.03 to 2.8 p.p.m. Of 10 spring waters, 6 contained no manganese, 3 contained 0.40, and 1 contained 7.8 p.p.m.; while 11 of the 16 streams contained from 0.02 to 0.09 p.p.m. of manganese

Perhaps the most notable occurrence of manganese was the so-called "manganese calamity" of Breslau, Germany, in the spring of 1906.[3] Here the River Oder rose and overflowed the well-field, increasing the iron content to 440 p.p.m. and the manganese content to 220 p.p.m. This load was too great for the deferrization plant, manganese passed the filters, and the supply was temporarily abandoned. At Breslau it was generally considered that during the preceding dry period the manganese in the peaty top soil had become dissolved as sulphate, which easily-soluble salt readily leached into the water-bearing layer below, following the high water.

It is undoubtedly true that the presence of manganese in many waters would have attracted little attention were it not for its effect on the control of chlorine treatment by the orthotolidine test. Buswell and Boruff[4] found that manganese interferes with this test, and Enslow in discussing their paper gave examples thereof.

Fosberg[5] showed that manganese in surface waters reacted like chlorine; unfiltered waters gave a positive reaction for chlorine, but those filtered through paper to remove the manganese did not so react.

In New Jersey[6] considerable difficulty has been experienced because of this interference of manganese with the ortho-tolidine test. In practice, when the manganese fluctuates, the "chlorine blank" is interfered with and the determination of the proper dose of chlorine is made difficult.

There are also others who have observed the interference of manganese with the ortho-tolidine test, and the following phenomena have come under the writer's observation.

Manganese in the Wanaque Reservoir.—The Wanaque Reservoir is located in the Jersey highlands. It is designed to supply 100 Mgd. to the populous district of northeastern New Jersey, including the cities of Newark, Paterson, Passaic, Clifton, Montclair and Kearny. At present a portion of the district, as well as the city of Bayonne in addition, is being supplied with an average of about 25 Mg. daily. Later in the year the cities of Paterson, Passaic and Clifton, and perhaps another city in the district, will begin taking water from this source. The reservoir is in a favored location and stores 28,010,000,000 gal. of water, having the following average chemical composition during 1930, its first year of use.

The valley of the Wanaque is one which has been scoured out by glaciation and then refilled with glacial deposits. At the dam site these deposits reach a depth of 110 ft.

The terrain is hilly and the half-dozen feeders drain areas sparsely covered with soil. Only 1.5 per cent of the flooded area was swampy in character. The bottom of the reservoir was well cleaned but was not stripped to more than 10 ft. below the flow line excepting in the vicinity of the dam.

In the catchment area contributing to the reservoir are Sterling and Greenwood Lakes, the latter receiving the runoff from 27.1 sq. miles; the catchment area above the reservoir dam is 94.4 sq. miles.

The catchment area is a highly mineralized one on which were located some of the earliest American forges, the ruins of one now being beneath the waters of the reservoir. Contributing to it is the drainage from Peters' Mine, one of the existing iron mines of the Ringwood Company. This mine is in active operation and other mines in the vicinity have been worked intermittently for years.

The reservoir began to fill on March 23, 1928. It was full in March, 1929, drawn down 10 ft. during that year, and refilled on March 4, 1930, shortly before it was placed in service.

With an average iron content of only 0.16 p.p.m. no

TABLE I*

Constituent	P.P.M.	Constituent	P.P.M.
Turbidity	5.	Alkalinity	.14
Color	13.	Total Residue on Evaporation	40.
Oxygen consumed	3.6	Suspended residue on Evaporation	0.5
Nitrogen as Free Ammonia	0.015	Carbon dioxide	1.5
Nitrogen as albuminoid ammonia	0.152	pH Value	7.0
Nitrogen as nitrites	.001	Iron	0.16
Nitrogen as nitrates	.05		
Chlorine	2.0		
Hardness	20.		

*Analyses by the Wanaque Laboratory, A. E. Griffin, Analyst, by courtesy of J. W. Griffin, Superintendent of Operations.

attention was paid at first to manganese. Soon after, the "chlorine blanks" in the ortho-tolidine tests for chlorine began to vary unreasonably and proper dosage was difficult. This condition was first observed in May, 1930, when the bottom water was beginning to stagnate and to affect gradually the water drawn from the intermediate intake, about 35 ft. below the flow line of the reservoir. Later in the summer when the oxygen had disappeared and the carbon dioxide was high in amount, the trouble became serious.

The set of depth samples collected on July 4th, 1930, shows the peculiar condition of the reservoir. Results of analyses of these samples are given in Table II.

The source of the manganese was undoubtedly the bottom of the reservoir where oxygen was absent, hydrogen sulphide present and carbon dioxide abundant. Tests made recently show that the amounts of manganese in the feeders of the reservoir vary from 0.03 to 0.06 p.p.m. as compared with a manganese content of 0.13 p.p.m. in the reservoir water. At this writing, (May, 1931), the manganese content is apparently decreasing rapidly as the effect of the spring overturn recedes and the reservoir clears. Consequently, troubles with the ortho-tolidine tests are absent for the present. Difficulties, however, are expected in the fall of 1931 and again in the spring of 1932. As the reservoir ages, however, it is expected that these troubles will become minimized.

While high amounts of manganese have been found during the past year, it is probable, as has been true elsewhere, that the manganese content of the reservoir water will decline as the fermentable organic matter in it decreases with the years.

While the effect of manganese on the ortho-tolidine tests is not the subject of this paper, it is one of vital importance for the sanitary control of the Wanaque supply. An indication of its seriousness may be gathered from the figures in Table I.

These figures show how easily one can mistake manganese for the chlorine demand of the water itself (chlorine blank) especially when water be taken from the lower half of a reservoir during a period of stagnation and high manganese.

At the Wanaque reservoir there is no fixed relation between the chlorine blank and the manganese content, as reported elsewhere.

It will be noted in Table I that the chlorine blank is about equal to the manganese content at a depth of about 20 ft. This relation persists until a depth of 40 ft. is passed when the manganese content increases more and more with each increment of depth. This may be due to variations in the degree of oxidation of the manganese, although such a statement is made with reservations. It will also be noted that the chlorine blank fails to increase below a depth of 60 ft. This is because of the counter influence of ferrous iron, as unpublished work of the Wanaque laboratory has shown.

So far no entirely satisfactory method of overcoming the disadvantages in estimating the dose of chlorine has been found, although the suggestion that the addition of ferrous sulphate might overcome the disabilities of the tests has been given a trial, so far without advantages.

Manganese in Industry.—At Baltimore, Bayliss[7] found that manganese interfered with the bleaching of yarn, a condition described by Goldthwaite[8] of the Mellon Institute of Industrial Research. Kneeland[9] reported trouble in laundries supplied by the Pittsburgh Suburban Water Co. with water taken from beneath the Ohio River at McKees Rocks, Pa. This water contained between 1.0 and 4.0 p.p.m. of manganese with only a trace of iron. It had a hardness of about 190 and contained some Crenothrix. The manganese is retained by the Zeolyte softeners without damage to the Zeolyte which is made from Glauconite.

At Biltmore, N. C., a bleachery takes water from the Swannanoa River and treats it in a modern rapid filter plant. Just above the intake of the plant was a new dam forming a reservoir of considerable size. Soon after starting the plant there was enough manganese in the filtered water (about 0.3 p.p.m.) to stain the walls of the filtered water basin and collect on the rubber squeeze-rolls in the washing machines. While this condition did not affect the cloth greatly, it caused considerable apprehension. It was overcome by adding 0.5 p.p.m. of chlorine to the raw water. The manganese in the raw water has decreased since the plant was first started three years ago, indicating unquestionably that its presence was due to the solution of the metal from the rich, organic soil in the bottom of the new reservoir.

Manganese in Pipes.—Manganese frequently coats the inside services of aqueducts. Hale[10] described the coating of the Catskill Aqueduct with manganese and concomitant substances and stated that it was induced by the alkaline reaction of the inner surface of the concrete aqueduct. On the other hand, a coating which was high in manganese appeared in the Wanaque aqueduct, which is of steel, after a few months of use. Hale found that the application of a considerable dose of chlorine not only prevented the formation of new coatings, but loosened the old ones and caused them to slough off. The coating found on the Wanaque aqueduct was derived from a water which was always treated with a low dose of chlorine. The difference in observed effects is due probably to a difference in dosage, a small dose of chlorine in the case of the Wanaque aqueduct being insufficient to dislodge the manganiferous coating.

The writer feels confident that in the soft waters of the Atlantic seaboard, at least, either physico-chemical reactions or the presence of bacteria, including the manganese bacteria, may cause deposits of manganese in aqueducts and pipe lines, and it seems that whether or not coatings are formed depends upon a great many factors, among which are reaction, organic matter, organisms and iron content, as well as concentration of manganese.

Demanganization.—The methods for the removal of manganese parallel those for the removal of iron, although they are not so simple, and emphasis must be placed on certain factors which in deferrization plants are of less vital importance, because reactions are more rapid.

It may be stated as a basic principle, that manganous salts in alkaline waters absorb oxygen, oxidize slowly, and ultimately precipitate as manganic hydrates (hy-

TABLE II—COMPOSITION AT VARIOUS DEPTHS*

Depth below surface (ft.)	Color p.p.m.	Carbon Dioxide p.p.m.	Dissolved Oxygen % Sat.	Manganese p.p.m.	Chlorine Blank p.p.m.
0	10	0.5	106	0	0.03
10	11	....	105	0	0.03
20	22	1.5	90	0.05	0.06
25	15	7.4	40	0.05	0.07
30	14	....	27	0.06	0.10
40	10	8.5	31	0.14	0.17
50	20	....	29	0.36	0.25
60	12	....	22	1.10	0.30
70	13	....	35	1.90	0.24
77	16	12.2	0	2.40	0.15

*Analyses by the Wanaque laboratory.

drated manganic oxide). There seems to be no difficulty in the oxidation of manganous bi-carbonate or sulphate to the hydrated manganic oxide. The difficulty is in removing the latter from the water, or in absorbing the manganous salts and holding them until they may be oxidized.

That precipitation is relatively slow is shown in systems supplied with untreated ground water, from which small amounts of iron and manganese collect in the distribution system. For example, at Brookline, Mass.[11], before the deferrization plant was placed in use, the ratio of manganese to iron in pipe coatings increased with the distance from the pumping station along the force main and the pipes in the distribution system.

That organisms, Crenothrix and the manganese bacteria, play an important role in the removal of manganese from water, has been shown by von Wolzogen Kühr[12], Tillmans, Hirsch and Grohmann[13] and Janzig and Montank[14].

Von Wolzogen Kühr not only attributes the absorption of manganese salts from water to manganic oxide, but states that manganese bacteria play the chief role in oxidizing the manganese, which they do by biolysis. This point is still in controversy, and the writer's experience would incline him toward the opinion that the bacteria and the manganic hydrate which they accumulate, absorb the manganous salts and retain them while they are being slowly oxidized and changed from the colloidal state. One may not disregard the effect of the mass of precipitated manganic oxide with which the water comes in contact in filters and tricklers; neither the mass of zoögloeal jelly produced by bacterial growth.

If the biolytic action of bacteria were the essential agent in oxidizing manganese, the application of killing doses of chlorine at Biltmore, N. C., would have decreased rather than accelerated the removal of manganese by the mechanical filters there.

That the accumulations of bacteria on filtering material are important, is not to be denied. It was demonstrated at Brookline, Mass. Here, during the first months of operation of the deferrization plant, most of the manganese passed the tricklers and was partly removed by the filter sand, which was stained black. At present, all of the manganese is removed in the tricklers, through which the water passes after being aerated, and before being filtered. During 1930, this water contained an average of 0.65 p.p.m. of iron, 0.41 p.p.m. of manganese, and had a hardness of 39 p.p.m.

It may be true that oxygen and other gases produced by bacterial growth are more active than the same gases dissolved in water. If so, may not the increased effect be due to the greater concentration of the "nascent" gas at the point of liberation. In other words, the phenomena of surface contact and concentration are the important ones in demanganization.

The devices commonly used for treating waters for the removal of iron are also used for the removal of manganese, but preliminary treatment is more important in the latter instances.

In the softening process, manganese is readily removed by lime with the aid of ferric sulphate. Hopkins[15] found at Baltimore that the pH value must be maintained at 9.4 or higher to bring about the chemical precipitation of manganese with lime and ferric sulphate (chlorinated copperas).

As in the deferrization process, the manganese must be oxidized, coagulated, and the insoluble hydrated oxide removed by filtration. The coagulation of the small amount of manganic hydrate in dilute solution is the difficult step in the process.

Organic matter often interferes. Here pre-chlorination is sometimes advisable, but not to a degree sufficient to inhibit growths of organisms on the surfaces of the filtering material, tricklers and filters.

While hard waters, high in iron, may be purified easily, soft waters, low in iron and pH value, and high in organic content, present many difficulties. Some of these (e. g. Lowell, Mass.) may not be aerated to a high degree for fear of forming a resistant compound of manganese and organic matter. Others require the addition of an oxidizing agent, like chlorine or permanganate, to reduce the inhibiting organic matter.

Generally speaking, it is better to depend on surface contact with accumulations of hydrate and organisms, than upon overdosing with alkali, with the resulting increase in hardness. Aeration, contact with precipitated hydrate and organisms in a contact aerator, followed by filtration through sand, suffice to remove manganese from water.

While it is true that manganese zeolite, regenerated with sodium or potassium permanganate, may be used successfully, the methods in more common use are usually preferable. The devices designed for iron removal, with allowance for the slower oxidation of manganese, will meet conditions as a rule.

Excepting in certain cases, aeration should be thorough. Either high-head or low-head nozzles, cascades or a system of superimposed coke or gravel-filled trays may be used effectively. The latter system has the advantage of providing a large contact surface.

Contact aerators or tricklers should be deep enough to provide ample time of contact. The present tendency is toward the upward-flow type as used by Pirnie at Long Beach[16]. This is because of saving in head, greater facility for cleaning, and a longer period of contact. Rates of from 50 to 80 MgAd are usually satisfactory,—choice of rate depending upon the character of the water treated.

Storage of water before filtration is usually beneficial, especially with gentle agitation, and in many cases, storage may take the place of contact bodies. At Brookline (Mass.), Mr. F. F. Forbes arranged to have the trickler effluent pass through narrow channels at a considerable velocity, on its way to the filters. The results of this arrangement have been excellent.

For manganese, slow filters, operated at a rate of as high as 10 MgAd., are usually safer than rapid ones, although with ample pre-treatment, the latter may be used. In general, if the preliminary treatment be adequate, high rates of filtration may be used.

Acknowledgment.—The above is an abstract of a paper presented May 26 at the annual convention of the American Water Work Association.

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Emergency Aeration and Activated Carbon Feed at West Virginia Water Service Co. Plant, Charleston, W. Va.

EFFECT OF DROUGHT ON QUALITY OF WATER AT CHARLESTON, W. VA.

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AT Charlestown, W. Va., the Elk River flows into the larger Kanawha, and the water supply is secured from the Elk at a point about 1¼ miles above the confluence of these rivers. The Elk has a watershed of some 1,500 square miles and prior to 1930 the lowest daily flow on record was 9 M. G. D. During the summer and fall of 1930 the daily flow of this river was reduced at times to 2.5 M. G. D. Gravel dredging operations in the Elk River have converted the lower stretches for a distance of over 2 miles into a long narrow pool about 12 ft. deep. There is a low dam in the Kanawha River below its confluence with the Elk which creates a backwater in both rivers for a considerable distance upstream. The sewage of the city of Charleston is discharged untreated through numerous outlets into the Kanawha and into the lower portion of the Elk below the water intake. In addition to this, the city had made a practice of dumping garbage into the Elk River at a point well below the intake. This highly putresible material added greatly to the organic load which the river had to assimilate. Under normal conditions the flow of the Elk is downstream and the quality of the raw water at the intake is quite satisfactory for purification.

Quality Began to Deteriorate in June.—Although stream flow in the Elk River was low during the early part of 1930, the quality of the water as secured from the intake did not begin to deteriorate until early in June when the numbers of bacteria showed a decided increase. Inspection of the river showed clearly that as the stream flow in the Elk decreased, water from the lower stretches of the river was drawn toward the intake. Later this tendency became pronounced and visual observations and float tests showed that the current in the Elk was actually moving upstream.

On June 27th, pre-chlorination was commenced, using doses sufficient to carry a slight residual chlorine through the filters. Unpleasant tastes and odors began to be noticeable in the treated water about the middle of July. The taste and odor was of an aromatic vegetable nature, sometimes becoming quite fishy. These tastes and odors were due to several causes, chief of which were: decomposing organic matter, algae, and to some extent, industrial wastes. As would be expected, analysis of the water showed the dissolved oxygen to be decreasing and the oxygen consumed increasing.

Apparatus for feeding ammonia in solution was devised and pre-ammoniation was started on July 20th and was continued until August 1st. Various ratios of chlorine to ammonia were tried and the doses were varied over a wide range. It was finally decided that this treatment only intensified the unpleasant odor and it was discontinued.

Another experiment was tried out thoroughly during July, based on the theory that very heavy coagulation might improve the situation. Artificial turbidity was produced by the addition of clay to the raw water and heavy doses of alum were applied. Little improvement was effected by this treatment.

Microscopic examination of the water revealed many forms of plankton which are associated with unpleasant odors in water supply. During the latter part of the summer and all through the fall, a considerable section of the river was treated at regular intervals with copper sulphate applied in bags dragged by a motor boat.

Aeration System Installed.—The oxygen deficiency of the water became so pronounced by early August that aeration was considered essential as a part of the purification process. Temporarily, some aeration was

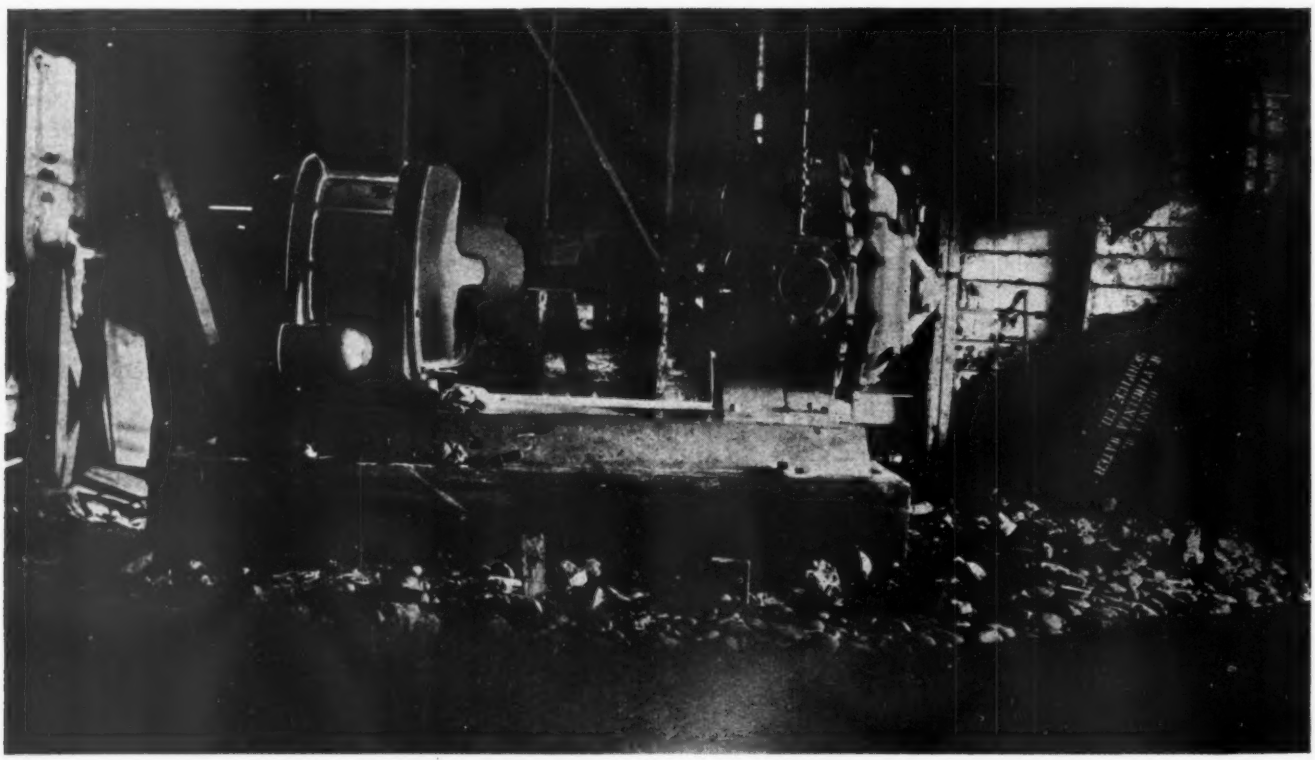
secured by installing a grid of perforated pipes at the inlet to the coagulation basin and forcing air into the water by means of the air compressor normally used for washing filters. A new coagulation basin was in course of construction at this plant and was completed about the middle of August. This basin was of sufficient size to give 3 hours retention in addition to the 6 hours available in the old basin. In view of the emergency then existing it was decided to install a more thorough aeration system in the new basin before turning it into service. Nozzles were carefully considered and discarded because the physical equipment and layout of the plant were unsuited to their use and also because of the time required for construction. The plan finally adopted consisted of bringing the raw water into the basin by means of a header at the bottom of the inlet end and extending clear across the basin. This header was provided with ten 8 in. riser pipes with their tops set about 6 in. above the water surface of the basin. Baffles were provided to prevent undue agitation. A header for compressed air was then laid along the top of the basin wall with one inch air lines running into each of the risers and extending almost to the bottom after the manner of an air lift. Compressed air at 10 lb. pressure was furnished by a Nash Hytor compressor rated at 500 cu. ft. per minute. The normal pumpage at this plant being about 6.5 M.G.D., the average air applied was 0.11 cu. ft. per gallon of water. In addition to this it must be remembered that the water issuing from the risers was thrown into the air about two feet with a free fall to the basin surface.

Work on this aerator was started on Aug. 26th and the basin and aerator were completely in service on Sept. 6th, a remarkable construction achievement. Numerous tests show that this aerator consistently increased the dissolved oxygen from about 30 per cent saturation to about 75 per cent saturation or about 150 per cent. Odors escaping from the aerator were very noticeable, indicating that it was performing its function in this respect.

Powdered Activated Carbon Applied.—Just prior to the occurrence of this taste and odor trouble at Charleston, considerable success was reported by Spalding at Hackensack in the removal of taste and odor by feeding small doses of powdered activated carbon into his coagulating basins. An Aug. 11, a dry feed machine was set up at Charleston to feed into the coagulated water and a dose of 20 lb. per M.G. of Nuchar No. 2 was applied to the water as it entered the filters. Within a few hours all of the filters were showing maximum loss of head and, it being impossible to wash them rapidly enough to keep up the supply, the carbon feed was discontinued at that point. During this treatment the filter effluent showed some improvement in taste but the results were by no means perfect.

The next day the point of carbon application was moved to the inlet of the coagulation basin and the same dose applied there. The improvement was so slight that the dose was gradually increased to 40 lb. M.G. I believe it is a fair statement to say that a slight improvement was effected by this treatment. The carbon feed was continued until the end of the emergency. After the second basin became available, a split carbon treatment was tried with no apparent improvement in the results.

Super and De-Chlorination.—On Sept. 22 an additional treatment for odor and taste was instituted consisting of superchlorination and de-chlorination with sulphur dioxide. Doses of chlorine heavy enough to produce a residual of from 2 to 4 p.p.m. after sedimentation were used and the water was dechlorinated just prior to filtration to a residual of 0.5 p.p.m. An immediate improvement was noted and this process was continued in service for about a month when the character of the taste in the water suddenly changed for the worse. Experiments indicated that the super and dechlorination were intensifying the taste, probably due to the addition of sulphur. This treatment was then discontinued and the plant was put back on straight prechlorination with improved results.



Motor Driven Nash-Hytor Compressor Installed for Emergency Operation

Among the treatments tried during this emergency may be mentioned the additional of a coagulating dose of alum to the river over a section two miles long on two different occasions. This section of the river was also treated with hypochlorite of lime on several occasions in addition to the copper sulphate treatments already mentioned.

A Wallace & Tiernan Ammoniator was purchased about Oct. 30th and a number of carefully controlled experiments were carried out on the plant, using chlorine with ammonia. The results were not encouraging.

Laboratory Experiments.—Throughout the emergency, numerous laboratory experiments were carried out either in connection with the above described treatments or along lines of independent research. The use of potassium permanganate and the excess lime method were carefully investigated and discarded.

In order to avoid confusion, I would like to point out that the above described treatments on a plant scale were not only tried independently but also in conjunction with each other so that at times two or three methods were in use at the same time.

During the greater part of this emergency, a small experimental filter containing 30 inches of Hydro-darco was in constant operation on the plant effluent at a rate of 2 gal./sq. ft./min. The unit removed all of the taste and odor from the water except on a few occasions when an odor of intensity "1" was detected.

In connection with the above discussion it is important to know that at all times the bacteriological quality of the water delivered to Charleston is subject to a daily triple check. In addition to the routine examination made by the plant chemist, independent samples are examined each day by the city chemist and by the laboratory of the State Department of Health. On no occasion during the emergency did the water fail to pass the revised Treasury Standard by any of these tests.

Emergency Intake Constructed.—The situation at Charleston persisted so long that it was finally decided to construct an emergency intake to the Kanawha River just above Charleston. While the water in this stream was far from ideal, it was superior to that of the Elk. This job consisted in the construction of a 24 in. river intake, 240 ft. long, the installation of a 10 M.G.D. pump, the laying of 6,000 ft. of 20 in. C.I. pipe on land and 825 ft. of 24 in. Universal pipe under the river and connecting of this line with the piping at the filter plant. This job was started Nov. 17 and finished Dec. 24, a total of 38 working days. This emergency line was tested and operated for one day only. By Dec. 24 the flow in the Elk had increased to such an extent as to end the emergency and establish normal conditions.

Acknowledgement.—The foregoing is an abstract of a paper presented May 28 at the annual convention of the American Water Works Association.

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Explosion Hazards in Manholes

Explosion hazards in manholes, which constitute a somewhat serious situation in American cities, can be materially reduced by the making of extended surveys, says the United States Bureau of Mines, Department of Commerce, following the conducting of such a survey in Boston, Mass. Leakage of manufactured gas was found to be the chief source of combustibles in the manholes tested in Boston. The survey, conducted in cooperation with the Edison Electric Illuminating Co., was made as the result of several explosions in manholes, conduits and other underground openings which caused extensive loss of property and inconvenience to users of light and power. Conditions in Boston are similar to those prevalent in other large American cities, and if an explosion in an underground space should occur in a congested section, especially during a rush hour, enormous damage and loss of life might result, the Bureau points out.

The survey extended over a period of one year, during which time 1,765 different manholes were tested and 4,068 tests made, state G. W. Jones and G. St. J. Perrott in a report just made public.

As a general average, 6 per cent of the manholes tested contained combustibles or sewer gas at one time or another. The majority of these were in the city of Boston; manholes in outlying districts were usually free from gas. Two districts in Boston had manholes in which the combustibles were above the upper explosive limit and represented especially dangerous conditions.

Carbon monoxide and hydrogen were present in all samples which contained combustibles in amount equal to 25 per cent of the lower explosive limit, on which complete analyses were made. In no case were gasoline or other similar hydrocarbons detected.

Sewer gas was found in 9 samples. The amount of combustibles was always so low in these as to present no explosion hazard, but on account of the low oxygen content such atmospheres would suffocate workmen who entered them without respiratory protection.

The number of gassy manholes found during the different test periods declined steadily.

A simple portable testing apparatus was developed by the Bureau of Mines which would indicate whether the manhole atmosphere was explosive, or above the upper explosive limit, or deficient in oxygen, or, if below the lower explosive limit, the approximate percentage of combustibles present.

The results obtained indicate that it would be well worth while for utilities in other cities to conduct similar tests over an extended period and to promote similar joint action to that which is to be carried out in the Boston territory during the year 1931 by The Edison Illuminating Company of Boston and the Boston Consolidated Gas Company. Through this cooperation, a joint test crew will continue to operate, and in conjunction with the Bureau of Mines a report is to be expected for the calendar year 1931.

Further details are given in Report of Investigations 3109, copies of which may be obtained from the United States Bureau of Mines, Department of Commerce, Washington, D. C.

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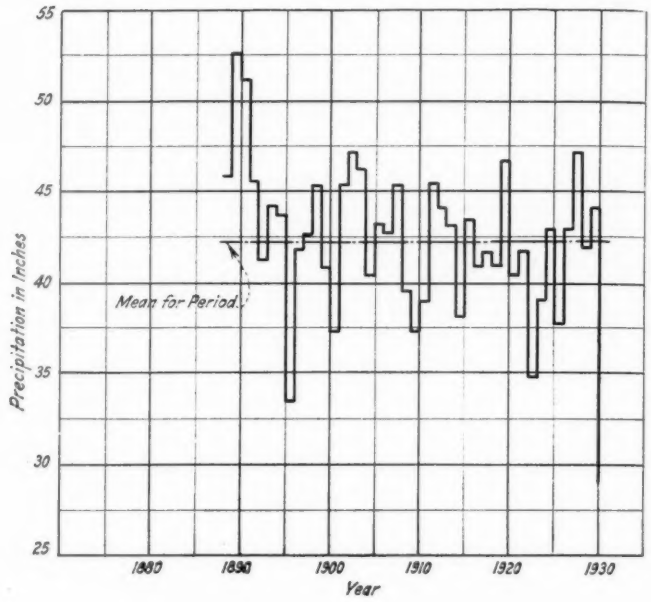
State and Municipal Borrowing in June

State and municipal borrowing for the first half of 1931 has been at the rate of almost $1,700,000,000 a year, far in excess of the largest annual total on record, according to figures compiled by *The Daily Bond Buyer* of New York.

The following table prepared by *The Daily Bond Buyer* of New York compares municipal bond sale totals in June for the past ten years:

	June	6 mos. ending June 30
1931	$115,801,038	$845,169,124
1930	153,699,089	743,055,609
1929	162,168,393	700,126,419
1928	137,213,105	777,119,833
1927	164 298,662	838,582,473
1926	145,616,332	743,313,662
1925	144,688,715	749,907,851
1924	286,507,401	830,779,456
1923	171,261,681	616,308,620
1922	169,748,241	734,157,276



Mean Annual Precipitation in Pennsylvania, 1888 to 1930

EFFECT ON WATER SUPPLY OF THE 1930 DROUGHT IN PENNSYLVANIA

By HOWARD E. MOSES

Assistant Chief Engineer, Pennsylvania Department of Health

PENNSYLVANIA was on the eastern fringe of the states chiefly affected by the drought, but this does not mean that the state did not suffer severely. In some sections of the state the drought made its appearance quite early in the year, but in general it was beginning to be noticed about the middle of May and was in full swing by the end of July, reaching what was thought to be its peak in August, because in September more abundant rains somewhere eased the situation, but in October it made a fresh start and continued at the end of the year in certain parts of Pennsylvania.

The Situation in Pennsylvania.—The situation is well stated in the following quotation from the Annual Summary, 1930—Pennsylvania Section—Report of the United States Weather Bureau.

"The outstanding feature for the year was the unprecedented drought that developed chiefly during the last six months. At the end of June there was an accumulated deficiency in rainfall of 5 in. or more in about one-fourth of the state. The dry regions comprised Berks, Lebanon, Lehigh, and Carbon counties in the eastern, and Adams, Franklin, Fulton, Bedford, Somerset, Cambria, Blair, and Huntingdon counties in the south-central portions of the state, respectively. Elsewhere the deficiencies were comparatively small, while there was a small excess in some of the northern counties. During the next four months, ending with October, the deficiency increased in those dry regions to 15 in. or more, and to 10 in. or more in fully three-fourths of the state. The average deficiency for the state, during those four months was 8.10 in., or 53 per cent of the normal. Small streams and ponds, shallow wells and thousands of springs dried up completely, and in many regions water was hauled for domestic uses, sometimes for long distances. * * * Intense heat began shortly after the middle of July and prevailed most of the time until the end of September. This increased the devastating effects of the drought. Pastures began to turn brown in many sections early in September, and it became necessary to feed ensilage to the stock. The drought did not end with the crop growing season, but continued during the remainder of the year. * * *"

Pennsylvania has had droughts in prior years. Records for the past 35 years show that beginning in 1895 drought conditions prevailed during 10 separate years. These are shown in the following table giving the year and approximate duration.

DROUGHTS IN PENNSYLVANIA—35 YEARS' RECORD

Year	Duration, Months	Year	Duration, Months
1895	3	1914	4
1900	3	1922	3
1908	5	1923	4
1909	3	1929	Started August, largely local
1913	2	1930	7

Rainfall Deficiency.—From the publications of the United States Weather Bureau—Pennsylvania Section—precipitation records for 1930 are available for the 12 months at 94 stations. Scrutiny of these records shows that with but one exception, at Center Hall, Centre County, there was a varying deficiency in the rainfall for the year. These ranged in inches from 1.92 at Montrose, Susquehanna County, to 23.94 at Somerset, Somerset County. These two places are practically diagonally opposite from each other across the state, Montrose being in the northeast and Somerset in the southwest. The mean annual precipitation for Pennsylvania as determined for 43 years, 1888 to 1930, inclusive, was 42.37 in. In 1930, the rainfall for the state at large was 28.82 in., a deficiency of 13.55 in., or roughly 68 per cent of the mean annual precipitation.

Center Hall showed a surplus of 0.21 in. Otherwise, except for Montrose (—1.92 in.) and Towanda (—2.73 in.), all of the other stations showed a rainfall deficiency of more than 5 in. for the year. It may be noted from the table which follows that the majority of the stations registered a deficiency in excess of 10 in., while 30 stations show from between 15 to 20 in. deficiency and 3 with more than 20 in.

Inches	No. of Stations
Under 5	2
Between 5 and 10	11
Between 10 and 15	47
Between 15 and 20	30
20 and more	3
Total	93
Center Hall (plus 0.21)	1
Total Stations	94

Stream Flow Records.—The records of stream flow n 1930 as compared with minimum flows of prior ears are interesting. Naturally the lack of precipitaton in 1930 was very definitely reflected in the lowering f streams. To illustrate this point records were secured rom the Department of Forests and Waters of Pennsylvania of the minimum recorded flows for the main drainage basins in the State, together with several of the principal tributary streams. These records cover the Delaware, Susquehanna and Ohio River Basins.

A study of the details indicates that for the streams taken, including a list of 14 stations, the lowest flow of record was found on 8 of these in 1930. Four of the "minimums" were recorded in 1908, one in 1910 and the last one in 1914. Low water conditions prevailed in each of these three years.

All of these are large streams and while seriously affected by the drought, there was still water flowing. At the same time many fair sized tributaries became almost exhausted or failed completely and where these were used as sources of public water supply, then the water works officials were obliged to exert their utmost energies to provide auxiliary or emergency supplies.

Water Supply Problem.—The effect of the prolonged drought on public and private water supplies was naturally one if not the most serious problem. The greatest effect was felt in the south-central and southwestern sections of Pennsylvania. Elsewhere there were localities affected, but in general the drought area was confined to the sections thus described.

In these areas public water supplies relying upon small surface streams were early in trouble. Water works on the main streams and principal tributaries did not suffer from lack of water, but encountered other serious trouble in some instances because of the changed composition of the rivers due principally to the low flows. This situation was particularly acute in the southwestern part of Pennsylvania on the Monongahela and Allegheny Rivers. The conditions are well described for that section of the state in an article published in *Engineering News-Record* (May 21, 1931,) by L. S. Morgan, District Engineer of the Pennsylvania Department of Health stationed at Pittsburgh and in close touch with the serious problems arising in that section. Two paragraphs are quoted from this article:

"The Monongahela River was highly acid to a point about 25 miles above its mouth. Downstream from this point, the acidity was gradually decreasing until it was actually alkaline near its mouth during the extreme low flow period. This gradual reduction was not due to the inflow of alkaline diluting water from tributaries but was caused by the neutralization of the acidity, principally at industrial plants, of large volumes of the river water and the return of this alkaline water to the stream.

"In general some of the problems experienced by water works officials at purification plants treating highly acid and excessively hard waters were as follows:

1. Inadequate capacity of chemical feed equipment.
2. Production of abnormal quantities of sludge.
3. Inadequate sedimentation basin capacity.
4. Inadequate facilities for sludge removal.
5. Shortened filter runs.
6. Increased cost of treatment.
7. Failure to effect satisfactory reduction in hardness to meet adopted plant standard."

On the Allegheny River trouble was experienced caused by the changing characteristics of the river water. Ascribable to the long continued drought a taste characteristic was acquired by the Allegheny River and the Ohio River below Pittsburgh, which was described as musty, moldy, burnt leather and commonly referred to as "river taste." Various methods were used at the plants in Pennsylvania and lower down the river to combat this taste, such as the excess lime treatment, ammonia-chlorine process, activated carbon, and potassium permanganate was also employed. These met with varying success.

Another unusual occurrence happened on the Allegheny River and we understand farther down stream on the Ohio in the high chlorine demand of the river water. The cause of this was not discovered, but it happened on the Allegheny River above Pittsburgh shortly after the first of the year and the water plants there which were equipped to meet the ordinary chlorine demand found the capacity of their chlorine equipment inadequate. This condition existed for a few days, disappeared and then returned a second time for a shorter period.

Many examples might be cited of increased hardness, but perhaps the maximum encountered by any public waterworks was at Apollo where because of failure of the normal supplies, recourse was had to the Kiskiminitas River, and on one day the hardness was 1,900 parts per million. I am not certain as to what figure the softening plant here reduced this, but it would certainly try the resources of any plant accustomed to handling hardnesses of 300 or 400 parts per million.

Another natural result of the low stream flows was an increase in the sewage pollution factor, particularly acute where sewage treatment is not afforded, since the volume of water in the streams was not large enough to dilute the sewage to the usual degree.

Effect of Drought on Forests.—Aside from the immediate province of the waterworks man but presenting an interesting side light is the effect which the drought had in the forests. One brief reference to this will serve to illustrate this phase of the problem. This is quoted from the Service Letter, Pennsylvania Department of Forests and Waters, April 16, 1931, as follows:

"Measurements and observations taken on the Mont Alto and Michaux State Forests in Franklin County indicate that the tree growth of 1930 was 25 per cent less than that of 1929, as a result of the drought. White pine showed a loss in diameter growth of 28 per cent. Similar conditions were observed in the Rothrock District in Huntingdon County and in the Penn District in Mifflin and Centre Counties.

"On the basis of an average growth of 40 cubic feet per acre per year, the 1,429,135 acres of State Forests suffered a loss of 14,290,000 cubic feet or 158,700 cords. On the basis of an average growth of 25 cubic feet per acre per year, the 13,206,000 acres of forest land in the State suffered a loss of 82,538,000 cubic feet. In addition, thousands of forest tree seedlings have died as the result of the drought."

Of course, the fire hazard in forests due to the prolonged dry spell and extreme heat was obvious. It became so serious that Governor Fisher on Oct. 28th, 1930, issued the following proclamation, which ban was lifted later in the fall after rains had relieved the situation somewhat:

"Whereas, An extreme drought now prevails in many sections of the Commonwealth, creating serious hazard by fire in forest and field; and

Whereas, In the interest of the protection of life, game, forest, field and all forms of property from fires, it has been recommended by the Board of Game Commissioners that it is necessary to invoke the provisions of statute passed to meet the emergency;

Now, Therefore, I, John S. Fisher, Governor of the Commonwealth of Pennsylvania, by virtue of the authority vested in me by the Act of Assembly approved May 12, 1925, do hereby proclaim and forbid the smoking of tobacco in any form and the building of campfires within woodlands or the burning of brush and other rubbish within woodland or within two hundred feet of woodland by all persons within the several counties of the Commonwealth during the hunting season fixed by the Board of Game Commissioners for 1930.

Any violation hereof will invoke the penalties prescribed by the cited statute."

Emergency Measures.—From the water supply standpoint the drought affected both public and private supplies. Many public water supplies were seriously disturbed, some streams which constituted the normal supply virtually failing, the storage reservoirs became empty and these conditions existed not at the end of the year but in mid-summer when the use of water is greatest.

This condition became aggravated the latter part of July in certain sections of the State. Naturally the smaller supplies were first affected, both streams and wells failing, but in the first part of 1931 the large impounded supplies felt the full effect of the prolonged drought. Reservoirs impounding millions of gallons were practically empty. One large water company having many such impounding reservoirs had their storage supplies reduced to approximately 20 per cent. Fortunately later rains served to replenish these storage basins and they are now from 75 to 80 per cent filled.

Conservation measures were promptly instituted. The Secretary of Health sent his engineers to the danger spots and issued a state-wide warning to conserve water where necessary, to search for additional supplies and particularly he warned the public to exercise care in using supplies where any uncertainty existed as to their purity. In local instances hand bills were distributed, the story was carried in the newspapers and in some of the most acute areas announcements were made in the churches and movie houses.

Particularly because of the business depression waterworks officials endeavored to maintain a supply for industrial purposes even if only a partial one. The industries cooperated by conserving and in some cases were able to secure supplies of their own. When the need arose, the industrial supply was shut off in the interest of the domestic supply.

The first effort of the water works officials was directed to acquiring water from any and every available suitable source. To this end they first turned in their auxiliary supplies if they had any, and then searched for additional ones. Use was made of surface streams, some high in acidity, wells were drilled, spring water was turned into the systems and the flow from mines was used in several instances where other supplies had completely failed. In a few instances water had to be hauled. One instance occurred where a 2½ mile pipe line was laid on the ground to pump water to a filter plant to augment an almost exhausted supply. Here also the wash water from the same filter plant was pumped back to the sedimentation basin. Waste condensor water, temperature 125 deg. F., was pumped directly into the distribution system. Pumps were installed on wells long unused and operated while there was any water to pump. A pump driven by a tractor was placed on the river bank. In one extreme case, water from drilled wells was pumped into temporary aeration racks. Again a stream containing mine drainage was treated with lime in the stream bed to neutralize the acidity and then filtered through a tub filter set up on the bank of the stream.

All these supplies had to be protected. To accomplish this, emergency chlorinators, mostly barrels using hypo, were set up on every unfiltered supply and in all kinds of places. One was placed at a well out in a cornfield, another in a tannery extract works and still another in a milk plant, and so on.

The Department of Health put five mobile laboratories into the field in order to make prompt check on emergency public supplies, but principally to render service in rural sections where the springs and wells used on farms and in villages had either failed or were sadly depleted. In connection with the failure of one public supply, examination was made of private supplies over a radius of 20 miles from this community, 700 samples being collected and examined in this one district.

The laboratory work started in July and continued until the end of the year. It was carried on in 40 counties and a total of approximately 5,000 water supplies were examined, mostly from private sources. It started again on a larger scale, with Federal Aid, in March, 1931, and is still continuing.

The need of such emergency measures is evident when it is considered that in 48 counties, more than one-half the entire state, 125 communities were obliged to use either auxiliary or emergency supplies, or both. In 41 counties there were 96 places where the normal supply practically failed and emergency measures were resorted to.

Under the circumstances described above the chances of typhoid fever outbreaks were materially increased and every effort was directed to providing adequate protection to these auxiliary and emergency supplies, which at times were used under considerable difficulty. A gratifying feature of this work is that no typhoid fever outbreak during this period could be attributed to any normal or emergency public water supply.

These results could not have been secured if there had not been cooperation between the Department of Health in its efforts to protect the public and the public itself in observing safety measures in the presence of potential health dangers, and most of all the cooperation of the water works officials under these trying conditions.

Acknowledgement.—The foregoing is an abstract of a paper presented June 26 at the fourth Annual conference of the Pennsylvania Water Works Operators' Association.

WATER RATES AT MILWAUKEE, WIS.—Water rates at Milwaukee, Wis., are made up of two items, a service charge of $2 per annum assessed against every meter, and a charge for metered water to cover the cost of pumping, purifying, and distributing, etc. For water furnished inside the city a uniform rate of seven cents per 100 cubic feet, equal to nine and a third cents per 1,000 gallons, and for water furnished outside of the city, ten cents per 100 cubic feet, equal to thirteen and a third cents per 1,000 gallons. Automatic sprinklers are charged $25 annually for 4-in. connections and $50 for 6-in. connections. No free water is furnished to anyone. The rate for public use (street sprinkling, parks, public buildings, etc.) are the same as for private consumers, except that the rate for fire hydrants is $10 per year, for large drinking troughs $150 per year, for small drinking troughs $75 per year, and for bubblers $50 for the season.

EDITORIALS

Is Economic Illiteracy the Cause of Panics?

Until the cause of a disease is known there is slight probability that its cure will be discovered. The disease called "business panic" has been studied by many generations of economists, yet its cause remains in dispute, and its prevention and cure a matter of debate.

No previous depression has witnessed the publication of so many hypotheses as to business cycles, yet little that is new has been suggested in explanation of these periodic afflictions. The standard treatises on this economic subject expound a score or more of hypotheses and usually leave the reader more doubtful than enlightened.

Perhaps the most commonly accepted explanation of business depressions is "overproduction." If this were a full explanation, then depressions should be short-lived, for shelves and storehouses are soon emptied. It must be admitted that the problem is not easy of solution. Hence it seems to call for a more thorough research than it has yet received.

When many books and thousands of articles have been written on a subject it is apt to be assumed that it has been deeply studied; but such an assumption is not always justified. There is, for example, a massive literature on weather, and at the same time a massive ignorance about the causes of weather. May not the same be true of business cycles?

Great modern wars have been accompanied by great price inflations, followed by great deflations and business depressions. It does not follow that all panics are war-begotten, nor even that a war necessarily causes a subsequent panic. We must look not merely at the destruction caused by war but at several other conditions that war usually brings about.

Since 1920 our per capita currency has been decreasing and prices have been falling, yet another panic has occurred. Panics have started near the crest of the commodity price curve, as in 1920, and they have started near the valley of the commodity price curve, as in 1893. They have followed close upon the heels of war, as in 1865 and 1920, and they have preceded a war, as in 1857 and 1914, the latter having just begun when the World War changed its course. Panics have occurred when the "machine age" was dawning, as in 1818, and a century later it was at full noon. Panics have followed an era of great railway expansion as in 1884, and they have occurred when railway growth was almost nil. Panics have happened when our banking systems were very flimsy, and again when they were very strong.

It has been suggested more than once that "easy credit" has been the ruin of many a good business house. Perhaps the rapid expansion of industry as a result of "easy credit" is one of the main causes of panics. When a firm has mortgaged its property heavily, both by bond issues and by notes, it is in no condition to weather a financial storm. No one realizes this better than the head of such a firm. Consequently no one is quicker to cut expenses than is such a manager, when clouds begin to darken the business horizon. But precipitate expense cutting is the sort of act that generates a business storm if many firms indulge in it simultaneously.

If excessive expansion of credit is the fundamental cause of panics, it follows that nearly all the preventives and cures now being advocated are worthless.

Overproduction of goods is doubtless a cause of business depression, but accompanying that cause there has always existed an overproduction of credit. Farmers complain bitterly of an overproduction of agricultural products, yet they importune congress to finance their enterprises with federal capital at low rates of interest!

Economic illiteracy is doubtless one cause of the recent business panic, for a business man who was thoroughly versed in the history of the business depressions of 1818, 1826, 1837, 1847, 1857, 1865, 1873, 1884, 1893, 1907, 1914 and 1920 could hardly fail to have anticipated the panic of 1929. Had the great majority of business men anticipated that panic, its effects would have been far less severe. The fact is that relatively few business men expected economic history to repeat itself in the form of a severe panic in 1929 or thereabouts. Our Federal Reserve Banking System (established in 1913) was commonly supposed to render severe panics impossible. Yet the panic of 1920 should have taught a different lesson. Moreover, Great Britain has experienced several severe panics since its present excellent banking system was developed.

While it is true that a good banking system reduces the severity of business depressions, no banking system has yet been devised that prevents panics. Credit giving requires a stronger curb than bankers can put upon it. Perhaps the only adequate curb will be better economic education.

H. P. Gillette

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Two Cities

A couple of paragraphs in a recent report of the water works department of an eastern city brought out fairly clearly a condition that exists in too many cities One paragraph pointed out that water was by far the cheapest commodity produced in that community, the price to the consumer being $0.03 ct. per ton. The other paragraph stated that many improvements and extensions to the water works were needed but the city had no funds to make them, nor could it borrow money because it had reached its debt limit. Had higher rates been in effect the city would have had a reserve fund for expansion. Now take the case of Racine, Wis. This city is just completing a program of progressive enlargement involving a total estimated expenditure of $2,000,000. A definite plan of improvements to meet the needs of a growing city was adopted in 1920, and it has been carried out progressively in an orderly manner and so far, entirely out of earnings. During the time that these improvements have been under way, the city has also made substantial progress toward retiring, out of water revenue, the bonds issued to finance the purchase of the plant. This city evidently had an adequate water rate.

SPRING MEETING OF THE NEW YORK STATE SEWAGE WORKS ASSOCIATION

THE New York State Sewage Works Association held its spring meeting in the recently completed Municipal Building at Freeport, L.I. The first day, Friday, June 5, was devoted to reading and discussion of technical papers and the following day was devoted to a forenoon trip of inspection to the new sewage treatment works at Freeport and Rockville Center, L. I. A picnic luncheon and beach party at Jones Beach—one of the recently completed units of the New York State Park System—was arranged by the local committee as the closing feature of a successful and enjoyable two-day meeting.

The arrangements for entertaining the ladies constituted an innovation for meetings of Sewage Works Associations. On Friday a trip was made to points of interest on Long Island, and a dinner dance for members and guests followed in the evening.

Lawrence Luther, City Engineer of Freeport, acting in the capacity of Chairman of the Special Committee on Program and Entertainment, and his able committeemen, Wellington Donaldson, Burdette Cleveland and R. E. Cook, are to be congratulated on the great success of the meeting.

For the first time exhibits by manufacturers of equipment and materials were arranged for the meeting. These were inspected by members between technical sessions.

The registered attendance was 132 and the elaborate dinner and dance at the Elks' Club drew 154 members and guests.

Technical Sessions.—The meeting was opened by President John F. Skinner, of Rochester, and welcomed by Russel S. Randall, mayor of Freeport.

The following papers were read and discussed:

"Present and Future Status of Sewerage and Sewage Treatment on Long Island," by A. F. Dappert, Division of Sanitation, New York State Department of Health. Discussion led by C. A. Holmquist, Chief, Division of Sanitation, New York State Department of Heath.

"Sanitary Engineering in County Health Departments," by R. E. Cook, Sanitary Engineer, Suffolk County, L. I. Discussion led by James L. Barron, Sanitary Engineer, Westchester County Department of Health.

Round Table Discussions occupied the afternoon session. The following topics were covered:

Prof. Earle B. Phelps, Columbia University, "What a Sewage Plant Operator Should Know."

Morris M. Cohn, Superintendent, Sewage Works, Schenectady, N. Y., "What Sewage Tests Can the Small Plant Operator Make?"

John F. Skinner, Sanitary Engineer, Rochester, N. Y., "Advantages and Disadvantages of Covered Sludge Drying Beds."

Horace H. Chase, Consulting Engineer, New York City, "Advantages and Disadvantages of Covered Settling Tanks."

Weston Gavett, C. E., New York City, "Gas Collection from the Digestion of Activated Sludge at Rockville Center, N. Y."

"To Cover or Not to Cover."—In an enlightening analysis of sludge bed performance at seven sewage works in New York State, John F. Skinner enumerated the several advantages of glass covered sludge drying

Convention Luncheon of New York State Sewage Works Association, June 5, Freeport, L. I.

beds and the relative merits of this newer development as compared to those of open beds.

For the plants analyzed the open bed area averaged 0.4 sq. ft. per capita. Those at the Irondequoit plant at Rochester save an area of 0.39 sq. ft. per capita which cost to construct 70 ct. per square foot. The minimum cost for the seven plants was found to be 27 ct. per square foot at Albion, N. Y., where no concrete was employed. At Rochester, 0.39 sq. ft. per capita, open bed area, seems sufficient and allows for 10 drawings per year with 10-in. sludge depth applied. In a six-month period of best drying weather 8.8 drawings of Imhoff tank sludge from 32,000,000 gal. of sewage per day is the average. The settling period in the tanks average 44 minutes only.

Mr. Skinner stated that one-half to one-third the area of covered beds appears to be equivalent to one of open beds. For open beds a formula is suggested as a guide to the area required:

$$\text{Area} = E\left(\frac{RS}{NTW}\right)$$

R = annual rainfall (inches)
S = settleable solids (parts per million)
N = number of months constituting drying season
T = Mean annual temperature (degrees Fahrenheit)
W = Mean wind velocity (miles per hour)
C = Coefficient, which varies with the type of sludge to be handled.

The comparative cost of open vs. covered beds based on experience will show an average of 75 ct. per square foot in the Rochester area for open beds as compared with $1.50 for covered beds.

The matter of selection of type of drying bed remains to be decided on the basis of local circumstances but covered beds may frequently be justified even at some additional expense. Mr. Skinner, "with apologies to Shakespeare," prepared below what Hamlet might have soliliquized had he in his time had to do with determining the design of sewage works.

ON SLUDGE BEDS

To glaze, or not to glaze, that is the question:
Whether 'tis better in the air, to suffer
The rain and snowfall of outrageous weather,
Or to take means against a flood of water,
And by opposing balk them? To rest,—to think,—
No more; and by thought to say we and
The odor, and the thousand natural smells
That sludge is heir to,—'tis a consummation
Devoutly to be wish'd. To rest,—to think;—
To think; perchance to fret;—ay, there's the rub;
For in that rest from deeds what faults may rise,
When we have cast aside this daily care,
Must give us pause; there's the respect,
That makes the daily grind so interesting;
For who would bear the quips and sneers of men,
The taxpayers wail, our friends digusted shrug,
Unrecognized worth, the law's delay,
The insolence of office, and the spurns
That patient merit of the unworthy takes,
When he himself might rest in peace of mind
With roofs of glass? Who would such burdens bear,
To grunt and sweat under a weary life;—
But that the dread of something untoward,
The chance of thunder, lightning, storms of hail,
Insurance cost, that oft puzzles the will;
And makes us rather bear those ills we have,
Than fly to others that we know not of?
Thus balanced schemes make cowards of us all?
And thus the brillancy of our designing
Is rendered dull by difficulties dour;
With enterprises of great pith and moment,
In this respect, inertia has its way,
And projects die a-borning.

Sludge Gas Utilized for Power Production.—Information concerning the practical side of converting the combustible gas evolved during digestion of sewage solids into power is scarce. For this reason the paper presented by Weston Gavett, C. E., has particular value and discloses from actual plant scale records data which represent some of the most dependable information on this topic yet available from American operations.

At the Rockville Center, N. Y., activated sludge plant, at present handling 1.3 million gal. of domestic sewage per day, gas from digesting sludge is utilized in gas engines to produce a part of the power requirement for plant operation. A mixture of solids from primary settling tanks and surplus activated sludge is digested in eight tanks of 63,000 cu. ft. total capacity. The tank roofs are depressed to keep scum submerged and the gas from the domes is piped to a neat appearing floating-cover style of gas holder with 5,000 cu. ft. capacity. Gas production at the present time (May) amounts to 13,000 cu. ft. per day and averages 1 cu. ft. per capita per day. The daily input to the digestors averages 330 cu. ft. of sludge (3 per cent solids) from the preliminary settling tanks and 1,600 cu. ft. of activated sludge (1.2 per cent solids). The heated digestion tanks are maintained at between 70 and 80° F. about 4,000,000 B.t.u. being required per day to mantain this range. About 3 tons of hydrated lime per month are added to the suldge input to maintain the ph value between 7.0 and 8.0 during digestion. The gas engines employed are:

No. 1—Buda 4-cylinder 4x5¼ in. direct connected to a Connersville blower from which 400 to 800 cu. ft. of air per minute can be obtained by varying the speed of the engine from the gas throttle.

No. 2—Buda 6-cylinder 4½x6 in. direct connected to a 25 k.v.a. generator.

Both have operated satisfactorily during the past year —No. 1 has operated a total of 2,800 hours and No. 2 1,450 hours. Because of relative efficiencies the smaller engine which is directed connected to the blower has been operated the greater portion of the time. Much of the gas produced went to heat the sludge during the past winter. Recently both engines have been operated 10 to 15 hours daily—the gas being used at night for sludge heating. An additional engine would allow more continuous power production and heat transfer from the cooling water would appear to be sufficient for maintaining the desired temperature in the digestion tanks. Jacketing the exhaust pipes has increased the heat conservation which makes this possible.

Between 20 and 30 cu. ft. of sludge gas per hour is required for each horsepower of work performed by the engines. From the present gas production of 1 cu. ft. per capita between 15 and 20 hp. is obtainable from each million gallons of sewage treated. Assuming 20 hp. available per million gallons and electric current worth 3 ct. per kw.h., the gas value from each million gallons of sewage treated amounts to $10.74. At the Rockville Center plant where the rate is 2 ct. per kw.h., the value is $7.16. In neither case has interest, depreciation or cost of operation been deducted from the calculated values.

Compared with commercial gas at $1 per 1,000 ft., sludge gas has a value of $13 for each million gallons of sewage treated.

At the present time (May, 1931) about half of the power requirement at the Rockville Center plant handling 1.3 million gals. of sewage daily is being produced by the gas engines.

Registration List.—The following is the registration list showing attendance at the technical sessions:

Aeryne, A. N., New York City.
Agar, C. C., Albany.
Anderson, C. C., Rockville Center.
Angell, J. M., New York City.
Baxter, Ray, Hamaroneck.
Barron, J. L., White Plains.
Bedell, A. S., Albany.
Bell, E. N., New York City.
Biele, F. J., Huntington.
Bird, G. C., Arlington, N. J.
Brigham, J. C., Albany.
Buck, G. H., New York City.
Buttenheim, E. J., New York City.
Carpenter, W. T., New York City.
Chase, H. H., New York City.
Cleveland, H. B., New York City.
Coffey, M. J., Freeport.
Cohn, Morris, Schenectady.
Cook, R. E., Riverhead.
Cornelius, J. D., Freeport.
Cowell, Ronald, Oyster Bay.
Cowell, John, Oyster Bay.
Cotton, E. R., Buffalo.
Cowles, M. W., New Milford, N. J.
Curry, T. M., New York City.
Dappert, A. F., Albany.
Downes, J. R., Plainfield, N. J.
Dickerson, F., Glen Cove.
Donaldson, W., New York City.
Dowd, J. E., New York City.
Drake, A., Buffalo.
Drexel, F., New York City.
Enslow, L. H., New York City.
Erdwurn, E., New York City.
Firth, E. W., New York City.
Fleming, W. C., York, Pa.
Gavett, W., New York City.
Glancey, J. B., W. Sayville.
Grieff, V., New York City.
Grieg, J. M., New York City.
Gyatt, W. P., Syracuse.
Hallock, E. C., White Plains.
Harrington, W. C.
Harrison, E. F., Philadelphia, Pa.
Hastie, J., Great Neck.
Holahan, F., Rochester.
Holmes, G. D., Syracuse.
Holmquist, C. A., Albany.
Howell, G. L., Buffalo.
Keeler, J. H., White Plains.
Kennedy, Wm., Glen Cove.
Kilroe, I. F., Lynbrook.
Kneale, J., Rockville Center.
Knoch, L. H., New York City.
Koch, F. J., Newark, N. J.
Laverty, F. J., White Plains.
Leigh, H. W., Tuxedo.
Kerslake, J. E., New York City.
Luther, L. L., Freeport.
Lyons, Mr., Great Neck.
Mallory, D. E., Babylon.
Manahan, I. D., Briarcliff Manor.
Marshall, Leslie, Hempstead.
MacCallum, C., New York City.
McKeenan, F., Freeport.
McKenne, J. L., Dundee.
Merse, Paul, W. Sayville.
Michaels, J., New York City.
Murray, J., Glen Cove.
O'Brien, E. F., Syracuse.
Ogden, H. N., Itaca.
Pearsall, H. E., Freeport.
Pease, H. D., New York City.
Phelps, E. B., New York City.
Powell, W. B., Long Beach.
Raisch, Wm., New York City.
Ryon, H., Albany.
Schneider, W. H., Freeport.
Schreiner, W. R., White Plains.
Scott, R. S., New York City.
Skinner, J. F., Rochester.
Slavin, A., New York City.
Smith, L. C. L., New York City.
Steelman, W. A., New York City.
Stevens, H. C., Hempstead.
Stewart, Walter, Long Beach.
Stoddard, J. M., Hempstead.
Strowbridge, J. C., Dundee.
Sutherland, H., Freeport.
Titus, W. O., Garden City.
Union, F. L., Amityville.
Van Denburg, J. W., White Plains.
Vanderwerkin, G. S., Long Beach.
Walker, C. L., Ithaca.
Watson, C. H., Great Neck.
Withington, W. C., New York City.
Wolpert, N. M., New York City.
Wyckoff, Mr., New York City.
Zeigler, F., White Plains.
Velz, G. J., Coatesville, N. J.

Manufacturers' Representatives.—The following is the registration list of manufacturers' representatives:

American Well Works Co.—G. H. Gaus, E. T. Ennes.
Aluminum Co. of America—E. J. Nelson, P. S. O'Brien, F. J. Began.
American Moniger Greenhouse—C. A. Andrews.
Chapman Valve Co.—S. J. Marsh, T. B. Payne.
Commersville Blower Co.—D. L. Dowling.
Dorr Co.—R. S. Rankin, E. Roco, W. A. Darby.
Dupont Co.
Eimer & Amend.—Mr. Faunce.
Fairbanks-Morse—A. H. Gadd.
Gurley Co.—C. C. Covert.
Intertol Co.—W. S. Dukro.
Laboratory Furniture Co.—S. Anker.
Link-Belt Co.—M. B. Tark.
Lord & Burnham—Walter Kelsey.
Pacific Flush Tank Co.—L. L. Langford.
Paradon Co.—E. K. Phelps.
Row Engineers, Inc.—J. I. Pouslow, R. R. Row, C. A. Badeau.
W. A. Taylor Co.—Mr. Taylor.
Turbine Equipment—W. L. Burns, Harold Sinclair.
U. S. Pipe & Foundry Co.—S. E. Linderman.
Wallace & Tiernan Co.—Mr. Clive, Mr. Johnstone.
L. A. Weston—L. O. Weston.
Yarnell & Waring—L. G. Chase.

▼

Developed Water Power of the World Doubles in Ten Years

The capacity of the water-wheels in the constructed plants of the world, according to estimates made by the United States Geological Survey, Department of the Interior, was 23,000,000 hp. in 1920, 29,000,000 hp. at the end of 1923, 33,000,000 hp. at the end of 1926, and 46,000,000 hp. at the end of 1930, an increase of 100 per cent in 10 years. The increase during the last four years in Europe has slightly exceeded that in North America. Outside of the United States the greatest increases in constructed plants have been in Italy, Japan, Canada, Germany, Switzerland, Austria and Sweden. A large percentage increase is also shown by New Zealand, Mexico, Brazil and India.

These estimates are based on information available in the United States Geological Survey, and for many countries the estimates of capacity of installed water wheels are based on data collected a year or more ago. The estimates for the United States and Canada are corrected to Jan. 1, 1931.

The estimates of potential water power are based on ordinary low water and an efficiency of 70 per cent in the plants. The installed capacity of machinery at constructed plants averages two or three times the potential power under conditions of low flow, and this accounts for the fact that in some countries the installed capacity equals or exceeds the estimated potential power.

NOTES FROM THE FIELD

Twenty-four Companies Purchased by Delaware Concern.—Twenty-four water companies were recently purchased from the National Water Works Corporation at New York by the Delaware Valley Utilities Company which incorporated in Delaware last May. The transaction is said to involve about $11,000,000. At the head of the Delaware company are John H. Ware, Jr., of Philadelphia, president, and John B. Stetson, formerly minister to Poland, vice-president. Mr. Ware, formerly owner of the Southern Pennsylvania Power Company, now a subsidiary of the Philadelphia Electric Company, will direct operation of the properties. The newly acquired water companies include: the Reading Suburban, Girard (controlling Hammond Water Company), Shenandoah Citizens, Lehighton, Mauchchunk, Freeland, Hegins, Citizens of Tower City, Williams Valley, Citizens of Scottdale and Greenville in Pennsylvania; Riverton and Palmyra, Washington, Laurel Springs, Ideal Beach, Frenchtown, Jamesburg, Tuckerton, Barnegat and Junction in New Jersey; Bolivar in New York; Ingleside in Tennessee, Pure and Mountain State Utilities in West Virginia.

Milford, Pa., Increases Water Rates.—Milford Water Co. of Milford, Pa., filed with the Public Service Commission a new schedule of rates effective July 1. Residents of summer homes will be charged at rate of year round service, instead of half rate as formerly. Yard fountains will pay $3 instead of $5 per year; the annual charge per year for each fire hydrant will be raised from $6 to $20; and there will be an increase from $3 to $5 in the yearly charge to stores. Instead of a flat charge of $20 a year for hotels up to thirty rooms, with extra charge for each bedroom in excess of thirty, the new rates will call for $2 a year for each bedroom. This company supplies water to the Borough of Milford, the home town of Governor Pinchot.

Adrian, Mich., Water Board Announces Year's Profits.—Annual report of the Adrian city water board, issued June 16th, shows a net profit for the year ending March 31, 1931, of $18,321. The gross profit was $25,890, of which amount $7,483 was used to pay principal and interest on the water board's bonds. It is stated $26,000 was spent during the past year on extensions and other improvements to the system, and a 10-in. main is now being laid on Lansing avenue to give additional service to manufacturing plants.

Franklin Water Company Acquires New Properties.—The water property and business of the New Jersey Zinc Co. in Warren County, Pa., has been purchased by The Franklin Water Co. Approval of the transaction was given by the New Jersey State Board of Public Utility Commissioners by the authorization of issuance of 920 common shares at $100 a share to finance the purchase, in addition to delivery of 210 common shares to the New Jersey Zinc Co. by the Franklin Water Co.

Scituate Water Bill Passed by Legislature.—The bill providing for the supplying of water by the town of Marshfield, Mass., to the Scituate Water Co. was amended to allow the purchase by the water company of the Humarock Beach Water Co. property in Marshfield, and thereupon passed.

New Jersey Completes Preliminary Water Surveys.—The preliminary surveys being conducted by the State Water Policy Commission for the acquisition of sources of potable water supplies in the northern part of New Jersey have been completed. It is stated that the commission now plans within a few months to seek approval from the State House Commission of a bond issue of $3,000,000 to finance the project, as purchases of sites and rights contemplated by the board must be approved by the State House Commission. Prof. John H. Gregory of Johns Hopkins University and Frank Barber were appointed by the commission as consulting engineers to survey Chimney Rock and other high level projects, prior to development of the tracts. It is said that their joint fee will be $2,500. A contract for $3,322 was awarded to the Osborne Drilling Co. of New York to make test borings in Lebanon and Tewksbury townships, Hunterdon County.

Dallas, Tex., Increases Income of Water Department.—Through growing sales of water to other than domestic users, H. E. Moore, secretary of the department, states that figures furnished by auditors checking their books indicated an increase within three years of $343,709.84. In 1927 there were fifty-eight industrial and commercial establishments providing their own water from private wells. There are now but seventeen such independent concerns. The report shows the income from non-domestic users 1927-28 was $79,245.26, and from the same source during the past year it was $260,575.73. When the campaign to sell more water was started the rate to non-domestic users was 22½ ct. a 1,000 gal., which has since been reduced to 15 ct., making it cheaper for large concerns to use city water than to operate wells.

Passaic Water Board Receives Fees Totaling $140,000.—James Wilson and Willard DeYoe of Paterson, Arthur S. Hughes of Passaic and William V. Negus of Clifton, the members of the original Passaic Valley Water Commission, were recently allowed fees of $35,000 each by Supreme Court Justice Peter F. Daly. Counsel for the commissioners had asked fees of $45,000 each. The commission had served three and a half years and in granting the $35,000 Justice Daly said it was "for the splendid service they have rendered the people."

Elizabeth, N. J., Passes Water Bond Issues.—The City Council passed on final reading two ordinances financing the acquisition of a municipal water system. One ordinance authorizes the issuance of $4,740,000 long-term water bonds to cover the entire cost of acquiring the system. The other ordinance calls for three temporary bond issues for purchase of two privately owned water companies in Elizabeth, the Elizabethtown Water Co. and Elmora System of the Plainfield-Union Water Co., for $4,264,277 and $275,000, respectively, and $15,000 for other items.

Quinlan Appointed City Engineer at New Orleans, La.—Patrick Quinlan, who has been acting as city engineer since the election of former engineer Bryson Vallas as general superintendent of the Sewerage and Water Board, has been formerly appointed to succeed Mr. Vallas. Mr. Quinlan has been connected with the city engineer's office for a number of years.

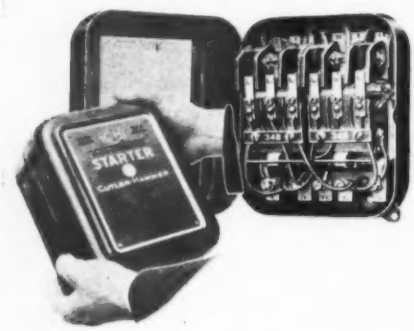
NEW EQUIPMENT AND MATERIALS

New Reversing Starter for Small A.C. and D.C. Motors

The development of a new across-the-line type reversing starter for D. C. and A. C. polyphase motors up to 3 hp. is announced by Cutler-Hammer, Inc., 311 N. 12th St., Milwaukee, Wis.

Reversing is accomplished by means of two mechanically interlocked magnetic contactors which are controlled from a remote point by means of a separate pushbutton master station.

Small size and high operating efficiency are features of this new starter. Overall size is 7 1/16 in. wide by 8 7/16 in. high by 4 7/16 in. deep. The contactors are a new three pole design. Silver to silver contacts reduce arcing and pitting to a minimum and assure maximum current carrying capacity at all times. The magnet structure consists of a laminated frame with a shading coil for alternating current and a brass shield for direct current.



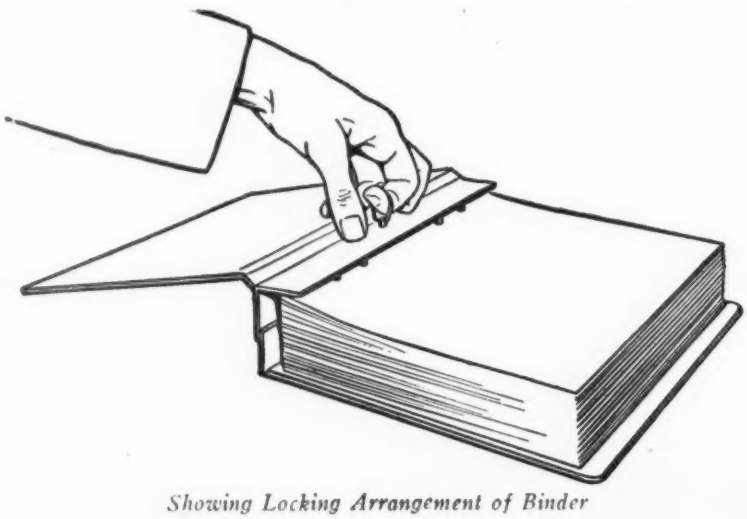
New Reversing Starter

These enclosed reversing starters are furnished in two types: Type SRA is arranged for two wire control only. It has a maximum capacity of 1 hp. Type SRB can be used for either two or three wire remote control. Blowouts are provided to give maximum capacity of 3 hp.

Meter Reader Binder

A simple and rugged binder for meter reader sheets is a recent product of the United Loose Leaf Co., 273 Spring St., New York, N. Y. The unique principle of locking mechanism allows for 100 per cent expansion, starting with any minimum capacity, and the aligner bar feature allows for insertion or extraction of any sheet in any part of the binder.

The binder provides flat opening for easy reference and entry making. Content is under tight compression from minimum to maximum capacity. Sheets may be readily removed or inserted at any point without disturbing the contents. The binder can be adapted to reader-sheets now in use. Flexibility of construction accommodates practically every standard or special punching specification. The binder can be made in canvas or imitation leather bindings, fibre board, bakelite, with exposed metal parts either nickel plated or chromium plated. It is made to fit any sheet size and any punching. Its operation is most simple—a slight turn and pull on the ring device immediately releases the entire contents.



Showing Locking Arrangement of Binder

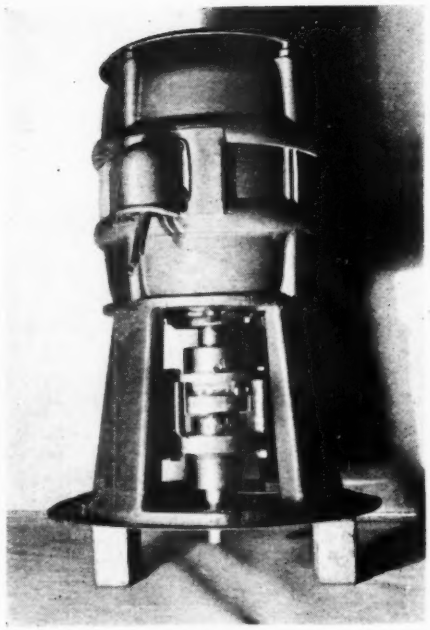
Vertical Pump Coupling

A vertical pump coupling for deep well turbine pumps, designed to eliminate the necessity of using a special hollow shaft motor, has been brought out by the Ideal Electric Manufacturing Co., Mansfield, O.

The pump coupling is stated to remove any possibility of backspin which often results in unscrewing shaft sections. Its use enables any standard solid shaft vertical motor to be used including slip ring, direct current and synchronous motors, since the coupling contains means of adjusting the position of the pump shaft as required.

The Ideal vertical pump coupling is made in two types—one with backspin release, and one without this feature. The coupling without the backspin release provides for thrust in both up and down directions as is required in some installations.

The Ideal vertical pump coupling with backspin release prevents backspin from unscrewing the shaft sections. In operation the lower sides of the pump rotors clear the pump bowls by a small fraction of an inch. When backspin occurs and a joint in the shaft starts to unscrew the shaft lengthens. The result is the lower end of the shaft drops till the pump rotors ride on the pump bowls. Further lengthening of the shaft caused by continued unscrewing action of the backspin causes the upper end of the shaft to rise. When it has risen about ½ in., the drive pins on the coupling are disengaged and the pump shaft then turns freely, preventing any further unscrewing of the shaft joints. Thus the backspin release acts before any joint can unscrew far enough (about 1½ in. minimum) to come apart.

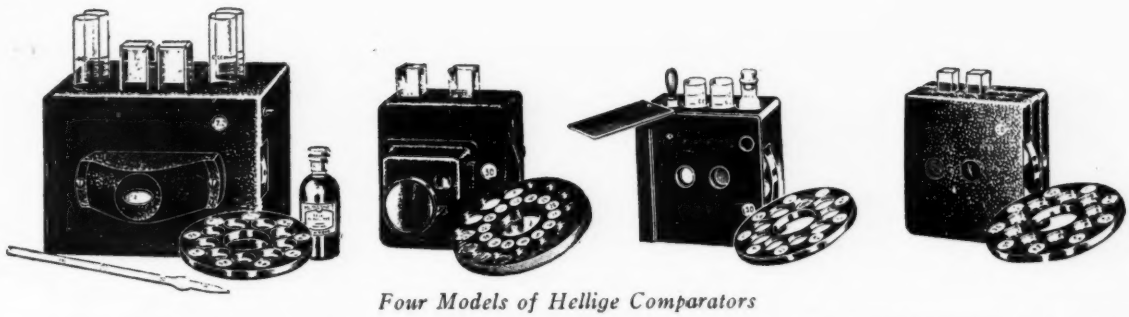


Ideal Vertical Pump Coupling with Backspin Release in the Open or Disconnected Position

Wide Range Indicator for pH Determinations

An indicator having a range from 1.0 to 11.0 pH is a product of Hellige, Inc., 179 East 87th St., New York, N. Y. It is stated that the colors for the various pH values are so clearly differentiated that an accuracy of 0.1 pH can be guaranteed between 4.0 and 9.4 pH, and 0.25 pH beyond the ends of this intermediate range. It is further stated that the indicator is not merely used for finding the approximate pH value of an unknown solution but also for very accurate general hydrogen ion control.

The Hellige indicator produces the best results when used with Hellige comparators. An outstanding feature of the comparators are the standards of colored glass. These will not fade and are mounted in discs of practically unbreakable material. Four models of Hellige comparators are illustrated herewith. The one at the extreme left is apparatus for the research or routine worker in the laboratory. For stationary use the apparatus can be supported on an adjustable metal stand. Special features of the ap-



Four Models of Hellige Comparators

paratus are the prism in dustproof housing for bringing the color fields into juxtaposition and the acid proof cemented cells with plane and parallel walls. The comparator can also be used with cells of larger liquid depth up to 40 mm., or depth reduction rods for tests with small quantities (0.5 cc.) of test solution. A special attachment for Nessler tubes is supplied for the analysis of water, sewage and industrial wastes with the standard methods of the American Public Health Association and American Water Works Association.

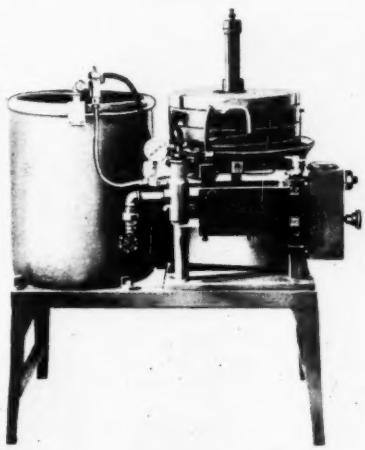
The comparator on the extreme right is a pocket outfit intended primarily for hydrogen ion determinations on excursions, during the manufacturing process in factories and whenever a small pocket size apparatus is desired. The apparatus contains all necessary accessories in the housing. The housing is of metal and has two hinged covers. The front cover takes the color disc, the back cover is for holding two graduated square test tubes, pipette with rubber nipple and a small bottle for indicator or reagent. Size of the apparatus, including color disc is 3½x3½x1¼ in.

The model next to the one on the extreme right embodies all conveniences in a portable outfit. The comparator consists of a wooden block with cover and hinged front plate. The wooden block takes the color disc with permanent color glass standards, two graduated round test tubes, pipette with rubber bulb and a small bottle for indicator or reagent. When the cover and front plate are closed, all parts and accessories are well protected, and the apparatus can easily be carried in the pocket without difficulty. The color fields are close together and give a good comparison, so that readings can be made with an accuracy of 0.1 pH.

The other model illustrated is similar to the pocket outfit, but in addition has a dustproof enclosed prism for bringing the color fields into juxtaposition. The color fields are enlarged by a removable magnifying lens in a metal frame, which can be attached sidewise when the apparatus is carried in the pocket. The result is a better and more accurate color comparison. The apparatus is provided with a threaded opening in order to mount the housing on a metal stand. The main advantage of this comparator model, however, is the fact that it employs color discs containing up to thirteen single standards. This adapts the apparatus ideally for tests within a wide pH range as covered by the Hellige Wide Range Indicator. Size of the apparatus including color disc and prism housing is 3½x3½x3⅜ in.

New Electrolytic Chlorinator

The contamination of small water supplies and swimming pools, especially those on private estates and summer camps, presents a health problem magnified during the summer months. When travel is heavy, water-borne epidemics originating from any of these sources are readily transmitted to unaffected localities. A new electrolytic chlorinator designed particularly for such supplies and for operation by persons entirely unfamiliar with the technicalities of chlorination has been brought out by Wallace & Tiernan Co., Inc., Newark, N. J.



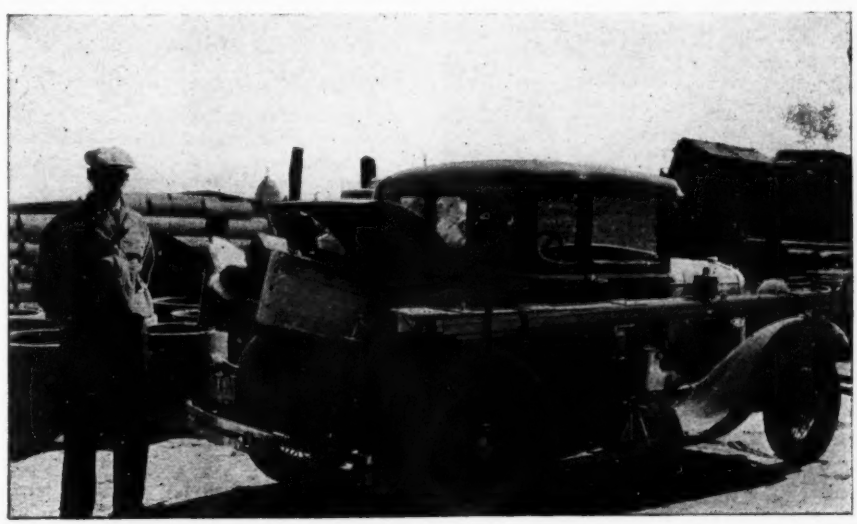
W&T Electrolytic Chlorinator

The W&T electrolytic chlorinator generates chlorine gas from a saturated brine solution, mixes the gas thoroughly with the correct proportion of water and delivers uniform chlorination at the point of application. The rate of gas generation is easily controlled by the simple turning of a rheostat. Should the water supply be accidentally cut off, gas generation automatically stops. Gas is generated only when it may be properly carried away. The rugged, sound construction of W&T electrolytic chlorinator is of rugged construction and its operation is inexpensive. Current consumption is the equivalent of one 150 watt bulb. Where public utility current is not available, the W&T electrolytic chlorinator, Type 6, can be used to operate from dry cells or storage batteries. Technical Publication 149 gives a full description and specifications.

Strongly built and attractively finished in Duco Gray, W&T electrolyic chlorinators conform to the highest standards of appearance.

Machine for Testing Culvert and Sewer Pipe

A testing machine designed for quick setting up and dismantling and for easy transportation for field use has been placed on the market by the Anderson Engineering Sales Co., Statler Bldg., Boston, Mass. It is stated the machine can be erected in 15 minutes ready for making tests and can be dismantled in 10 minutes for transportation. The overall size is 1 ft. by 5 ft. by 10 ft. and the net weight plus the dial is 600 lb. The machine has a 50,000-lb. loadometer. The machine will handle up to 42 in. 4 ft. pipe. For larger sizes a block and falls rigging should be used. The testing machine also is manufactured as a complete assembled unit with a patent unloading track and can be used in testing concrete beams, blocks, bricks and vitrified building products.



Bratt's Portable Pipe Testing Machine

WITH THE MANUFACTURERS

Link-Belt Pacific Coast Official Retires

The retirement has been announced of Harold H. Clark, after thirty years of loyal service to the Link-Belt Company and its subsidiaries. At the time of his retirement Mr. Clark was vice-president and assistant secretary of the Pacific Coast Division.

After his graduation as a mechanical engineer from Cornell University in the class of 1900, at the age of 22, he joined the Chicago plant of the Link-Belt Company. His first duties were in the drafting room, from which he was promoted to salesman.

In 1909 he left the Link-Belt for a short time, moving to Los Angeles, where he started a sales agency for Link-Belt and other companies. In 1931 he established the regular Link-Belt branch office at that city. When in 1920 the west coast branch offices of the company were organized as the Link-Belt Pacific Company, Mr. Clark was made vice-president and treasurer.

When the company acquired by purchase Meese & Gottfried Co. the coast organization became Link-Belt Meese & Gottfried Co., but the name was later changed to Link-Belt Company, Pacific Coast Division. As vice-president and assistant secretary of this organization, Mr. Clark had charge of sales and advertising activities.

Mr. Clark is held in high esteem in Link-Belt circles and in announcing his resignation the company expresses the regret of all his associates.

Harold H. Clark, Vice-president, Pacific Division, Link-Belt Company

W. L. Saunders, Noted Industrialist, Dies

William Lawrence Saunders of Plainfield, New Jersey, chairman of the board of directors of the Ingersoll-Rand Company, passed away June 25th in Teneriffe, Canary Islands. He was 74 years old.

Mr. Saunders, noted inventor, student and writer, particularly on subjects relating to industrial laws and politics, and a close friend of Woodrow Wilson's, was long identified with Democratic politics in New Jersey and was twice mayor of North Plainfield.

Descended from the earliest settlers of Jamestown, Virginia, and of Sir Edward Saunders, one of the Knights of the Horseshoe who discovered the Alleghanies, he was born at Columbus, Georgia, the son of Rev. William Trebell Saunders and a grandnephew of Robert Saunders, fourteenth president of William and Mary College.

After graduating from the University of Pennsylvania in 1876, as a bachelor of science, Mr. Saunders first took up newspaper work later becoming engineer in charge of dock construction at Black Tom Island, New York Harbor. While engaged in this work he invented a device for drilling, employing the tube and water-jet system. Many devices of his invention followed this when he became associated with the Ingersoll Rock Drill Company. He served as president of the Ingersoll-Rand Company, the successor to Ingersoll Rock Drill, and resigned from this position to become chairman of the board.

During the World War Mr. Saunders served on many important committees, and was at various times a member of the New Jersey Harbor Commission, the New Jersey Board of Commerce and Navigation, the Naval Consulting Board of the United States and the Advisory Committee of the Federal Trade Commission.

He is survived by two daughters, Mrs. Maxwell Evarts Perkins and Mrs. John E. Lancaster, Jr.

Keller to Handle Armco Southern Territory

Armco Culvert Manufacturers' Association of Middletown, Ohio, announces that Eugene Keller, Jr., until recently district manager of the Philip Carey Company at Memphis, has been made regional manager for Armco. He will be responsible for region No. 4, which includes: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North and South Carolina, Oklahoma, Tennessee and Texas.

Mr. Keller will extend Armco engineering service to the states in his region, making his headquarters at Nashville. He will contact state highway departments and the Bureau of Public Roads' officials, and will serve the promotional needs of the Armco culvert companies in his territory.

A native of New Jersey, Mr. Keller is a graduate in civil engineering of Cooper

Eugene Keller, Jr., Regional Manager for Armco.

Institute, Cooper Union and Columbia University, Extension Division. He has been engaged in various engineering activities in the east and south since his graduation from college. He was general superintendent for a firm of general engineering contractors of Nashville, specializing in highway and city paving projects, and for a short period was in the contracting business on his own account. In 1924 he joined the staff of the Philip Carey Company and has been with them up to the present time. He is an associate member of A. S. C. E.

R & H Company Elects New Officers

At the annual meeting of the directors of the Roessler & Hasslacher Chemical Company, Inc., held recently in New York City, the following officers were elected: Chairman of Board, W. F. Harrington; President, Hector R. Carveth; Vice-president, Mortimer J. Brown; Vice-pres. and Secy., Colby Dill; Vice-presidents, Milton Kutz and E. A. Rykenboer; Treas. Albert Frankel; Asst. Treasurer, August Heuser; Assistant Secretaries, M. D. Fischer, E. A. Howard and J. Carlisle Swaim.

Two of the newly elected vice-presidents, Dr. E. A. Rykenboer and Dr. M. J. Brown, are from Niagara Falls and will continue to make their headquarters there, while the newly-elected secretary, Colby Dill, will be located in New York City.

This company operates three plants, the largest of which is in Niagara Falls. The other two are in Perth Amboy, N. J., and El Monte, California. The company's central office is at 10 East 40th Street, New York, with branch offices in thirteen cities of the United States and a sales office in Mexico City.

Early in 1930 Roessler & Hasslacher Chemical Company, Inc., was merged with E. I. du Pont de Nemours and Company, Inc.

WATER WORKS AND SEWERAGE

AUG 1931

VOL. No. 8

A GILLETTE PUBLICATION

A STUDY OF BACTERICIDAL EFFICIENCY OF THE AMMONIA-CHLORINE TREATMENT

By H. H. GERSTEIN

Sanitary Engineer, Bureau of Engineering, City of Chicago

THE marked success with which the ammonia-chlorine treatment has met during the past two years throughout the United States in the prevention of tastes and odors which are commonly associated with the chlorination of water supplies, coupled with the simplicity of the process and the low operating and first costs, has made it expedient for Chicago to give the treatment careful consideration.

It was apparent from the beginning that in giving consideration to the use of the ammonia-chlorine treatment it would be necessary to determine carefully what the bactericidal velocity of the treatment was as compared with that obtained in ordinary chlorination treatment. A slowing up of the bactericidal action would be of great disadvantage if the treatment were to be applied at the Chicago pumping stations, because of the lack of protection it would afford to nearby consumers, many of whom receive their water in less than three minutes after it is chlorinated. If such delayed action actually occurred, and it was considered advisable to use the treatment, it would be necessary to provide sufficient detention period to obtain the required bactericidal effect before the water was pumped into the system.

The literature on this subject was not conclusive; some observers noticed a decided lag in bactericidal velocity, while others observed none. The investigation made by Holwerda[1] and more recently by Baker and Schmelkes[2] indicate that the widely varying effects observed were probably due to the application of the treatment to water of different hydrogen-ion concentrations.

Extensive research work was begun in September, 1930, under the direct supervision of Physical Chemist John R. Baylis and in collaboration with the writer. The technicians on the work were Senior Bacteriologist John H. Mills and Senior Chemist Oscar Gullans of Mr. Baylis' staff, and Junior Bacteriologist Catherine Weir and Senior Chemist Armada T. Weathers from the Health Department water analysis laboratory, who were detailed to the work through the courtesy of the Director of the Health Department Laboratories, Dr. F. O. Tonney.

Credit is due John R. Baylis and the technicians working under him, who were responsible for the carrying out of this work, and to the officials of the Department of Public Works, who provided all necessary facilities. Acknowledgment is also made of the cooperation received from Dr. F. O. Tonney and his staff.

It would be impracticable to present the results of all the various studies made in connection with the research work. The writer will therefore confine himself to such data as concern the bactericidal efficiency of the ammonia-chlorin treatment and related matters.

Technique Used in Bactericidal Experiments.—The water to be tested was prepared by adding a pure culture of Bacterium coli to 5-gal. portions of raw Lake Michigan water taken from the Dunne crib tunnel system. The raw water was then distributed into two liter glass stoppered bottles, the required amount of ammonia added to each bottle and the contents thoroughly mixed by shaking. The ammonia was permitted

[1] Holwerda, Meded, Dienst Volkgezondheit Ned. Ind. 17:251 (1928).
[2] Baker and Schmelkes, Research Publications 305, W. & T. Co. (1931).

TABLE I—DATA ON BACTERICIDAL EFFICIENCY, EXPERIMENT SERIES "A." EACH OF THE VALUES ARE AVERAGES OF THE RESULTS OF FIVE TESTS

NH_3 Applied P.P.M.	Contact Period	Chlorine Applied P.P.M.												Average Physical & Chemical Properties			
		.05 P.P.M. Cl_2		.10 P.P.M. Cl_2		.15 P.P.M. Cl_2		.20 P.P.M. Cl_2		.30 P.P.M. Cl_2		.40 P.P.M. Cl_2					
		% B coli Remaining	Res. Cl_2 P.P.M.	% B coli Remaining	Res. Cl_2 P.P.M.	% B coli Remaining	Res. Cl_2 P.P.M.	% B coli Remaining	Res. Cl_2 P.P.M.	% B coli Remaining	Res. Cl_2 P.P.M.	% B coli Remaining	Res. Cl_2 P.P.M.	Temp. °C	Turb. P.P.M.	M.O. Alk. P.P.M.	pH.
0	5 minutes	84.0	.006	15.0	.032	.086	.062	.33	.098	.40	.16	.052	.27	15.6	6.1	120	7.8
	30 minutes	79.9	.003	2.7	.018	.12	.032	.047	.062	.56	.11	.0028	.19	16.5			
	2 hours	75.6	.002	3.9	.010	.35	.018	.016	.038	.0081	.048	.014	.091	17.9			
	24 hours	52.3	0	.54	.001	.42	.002	.24	.006	.20	.011	.014	.040	19.2			
.1	5 minutes	82.9	.024	71.2	.052	50.3	.090	43.3	.16	11.3	.26	4.7	.37	15.5	7.2	120	7.8
	30 minutes	79.1	.005	7.2	.029	39.9	.076	8.9	.13	.92	.23	.26	.34	15.9			
	2 hours	67.3	.004	27.3	.024	7.4	.062	.52	.11	.0039	.20	.0003	.32	16.8			
	24 hours	17.0	.001	10.4	.010	.044	.032	.00006	.058	.00002	.13	.010	.25	19.4			
.2	5 minutes	60.7	.019	66.1	.056	49.5	.096	64.5	.15	16.4	.25	19.3	.35	17.8	10.0	120	7.9
	30 minutes	82.7	.012	41.5	.042	42.2	.082	30.5	.13	12.2	.23	.99	.34	18.4			
	2 hours	58.8	.005	44.0	.028	8.4	.064	.21	.11	.0036	.22	.0001	.32	18.7			
	24 hours	2.9	.001	.0017	.007	.0051	.026	.0002	.066	.00002	.18	.0013	.28	20.2			
.3	5 minutes	71.0	.024	72.4	.070	58.8	.13	100	.18	81.6	.27	20.3	.36	18.9	5.5	118	8.0
	30 minutes	87.8	.016	67.0	.054	44.4	.12	27.2	.14	14.3	.25	6.8	.35	19.6			
	2 hours	42.5	.012	19.7	.041	7.7	.10	1.9	.11	.085	.23	.0081	.34	22.6			
	24 hours	1.08	.003	.0004	.031	.00013	.063	.0008	.071	0	.20	0	.31	23.4			

to remain in contact with the water for 30 minutes, after which time the chlorine was added and the contents of the bottles shaken thoroughly before the 5-minute contact samples were withdrawn.

The bactericidal efficiency was determined by examination of samples withdrawn by means of a sterile pipette at intervals of 5 minutes, 30 minutes, 2 hours and 24 hours after the chlorine had been added. These samples were immediately placed in sterile bottles which contained 1 cc. of a 5 per cent solution of Bacto-peptone. The peptone solution was used for the purpose of stopping the bactericidal action immediately by removal of the residual chlorine. Five portions of each dilution were planted in lactose broth. An organism was assumed to be B. coli of the E. M. B. transfer showed the characteristic appearance of the strains of organism added to the raw water and no further confirmation tests were carried out. These growths on E. M. B. plates which were questionable were confirmed in second lactose broth.

Determinations of hydrogen-ion concentration, methyl orange alkalinity and turbidity were made on each of the samples of raw water used. Determinations of residual chlorine were made by use of the standard method of the A. P. H. A. employing standard orthotolidin solution. Observations of temperature were made at each stage of the work.

Lag in Bactericidal Velocity.—The results of the studies show that within the limits of the experiments and for the same chlorine dosage there is a marked retardation in the bactericidal velocity when the water is treated with ammonia and chlorine, as compared with water treated with chlorine alone, the lag being more pronounced with increased application of ammonia. However, after the initial retardation, the ultimate efficiency is greater in ammoniated water than otherwise and increases to some extent with increasing dosages of ammonia.

The effect of the various combinations of ammonia and chlorine applied on the bactericidal velocities and efficiency is shown in Table I, and is plotted in chart form in Fig. 1. With 0.2 p.p.m. chlorine application the bactericidal effect obtained after 5 minutes, using

TABLE II—EFFECT OF VARYING THE AMOUNT OF NH_3 ON VELOCITY OF BACTERICIDAL ACTION; DATA SCALED FROM FIG. 1 (EXPERIMENT SERIES "A")

Per Cent Removal of B coli	Time Required To Obtain Bactericidal Effect							
	.1 P.P.M. Cl_2				4 P.P.M. Cl_2			
	0 NH_3	.1 NH_3	.2 NH_3	.3 NH_3	0 NH_3	.1 NH_3	.2 NH_3	.3 NH_3
90%	.2 hrs.	24 hrs.	4 hrs.	3 hrs.	.02 hrs.	.06 hrs.	.12 hrs.	4 hrs.
99%	9 hrs.	>24 hrs.	8 hrs.	6 hrs.	.04 hrs.	.2 hrs.	.5 hrs.	1 hr.
99.9%	—	>24 hrs.	15 hrs.	10 hrs.	.07 hrs.	.7 hrs.	9 hrs.	2 hrs.
99.99%	—	—	20 hrs.	15 hrs.	.2 hrs.	1.5 hrs.	1 hr.	3 hrs.
99.999%	—	—	30 hrs.	20 hrs.	—	5 hrs.	1.5 hrs.	4 hrs.
99.9999%	—	—	60 hrs.	30 hrs.	—	24 hrs.	4 hrs.	5 hrs.
99.99999%	—	—	—	—	—	—	>24 hrs.	10 hrs.

TABLE III—STUDY OF EFFECT OF TURBIDITY IN WATER ON BACTERICIDAL EFFICIENCY OF AMMONIA-CHLORINE TREATMENT

.2 P.P.M. NH_3 – 4 P.P.M. Cl_2 Applied.

Experiment Series	Time of Contact	.2 P.P.M. NH_3–4 P.P.M. Cl_2 Applied		Average Physical & Chemical Properties.		
		% B coli Remaining	Residual Chlorine P.P.M.	Turbidity P.P.M.	pH	Temperature Range °C.
"A"	5 minutes	19.3	.35	10.0	7.9	17.8°C. To 20.2°C.
	30 minutes	.99	.34			
	2 hours	.0001	.32			
	24 hours	.0013	.28			
"B"	5 minutes	37.0	.35	10.4	7.8	19.5°C. To 23.3°C.
	30 minutes	.52	.35			
	2 hours	.0004	.34			
	24 hours	.0002	.25			
"C"	5 minutes	32.1	.38	5.6	7.8	22°C. To 22.8°C.
	30 minutes	.20	.39			
	2 hours	.0004	.38			
	24 hours	0	.33			
"D"	5 minutes	39.0	.16	55.0	7.8	21.6°C. To 23.0°C.
	30 minutes	15.4	.14			
	2 hours	.033	.13			
	24 hours	.0005	.058			

no ammonia, is not equalled by the ammonia-chlorine combinations until after 5 hours of contact. A longer period of contact, however, results in greater bactericidial efficiency when ammonia is used. With 0.4 p.p.m. chlorine application the same general effect is observed but the period in which the retardation in bactericidal velocity occurs, due to the presence of ammonia, is shortened to 2 hours. This indicates that increasing the ration of chlorine to ammonia hastens the bactericidal effect. Figure 2 has the same data plotted in a different form. With chlorine alone applied there is very little difference in the bactericidal efficiency between the 5-minute and 24-hour contact. However, with ammonia present there is a decided difference in the effect after the 5-minute and 24-hour periods, the difference being greater with the larger amounts of ammonia present.

The effect of increasing amounts of ammonia on the velocity of bactericidal action is shown in a different form in Table II. The data in this table was obtained by scaling off the values from the charts in Fig. 1. With 0.4 p.p.m. chlorine application there is 99 per cent removal of the B. coli in 2.5 minutes when no ammonia is present, and in one hour when 0.3 p.p.m. ammonia is used. With the same chlorine dosage, 99.9 per cent removal of the B. coli occurs in 4.2 minutes with no ammonia, whereas it takes 2 hours to obtain the same effect with 0.3 p.p.m. ammonia. Almost complete removal of the B. coli is obtained in 10 hours with 0.3 p.p.m. ammonia and 0.4 p.p.m. chlorine, but it takes over 24 hours to obtain the same effect with the same chlorine dosage and only 0.2 p.p.m. ammonia.

Effect of Temperature.—The lowering of temperature of the water has a decided effect in reducing the bactericidal efficiency of the ammonia-chlorine treatment, as is shown in Fig. 3. The temperature range was controlled between the limits 0° to 20° C., which

TABLE IV—EFFECT NH_3 AND TEMPERATURE ON PERSISTANCE OF RESIDUAL CL_2 IN A TURBID WATER (EXPERIMENT SERIES "E")

(1.0 p.p.m. CL_2 APPLIED)

CONTACT PERIOD	RESIDUAL CL_2 P.P.M. (O.T. TEST)					
	0-2°C.		10-12°C.		20-22°C.	
	0 NH_3	.5 NH_3	0 NH_3	.5 NH_3	0 NH_3	.5 NH_3
5 MINUTES	.60	.65	.60	.60	.60	.65
30 MINUTES	.40	.65	.45	.60	.40	.65
2 HOURS	.30	.65	.30	.65	.04	.60
24 HOURS	TR.	.62	.TR.	.55	0	.45
48 HOURS	—	.62	—	.55	—	.31
120 HOURS	—	.55	—	.45	—	.03
264 HOURS	—	.30	—	.24	—	—
480 HOURS	—	.20	—	.12	—	—
528 HOURS	—	.20	—	.12	—	—

* TURB = 104 P.P.M. – pH 7.6 – M.O. ALK. 120 P.P.M.

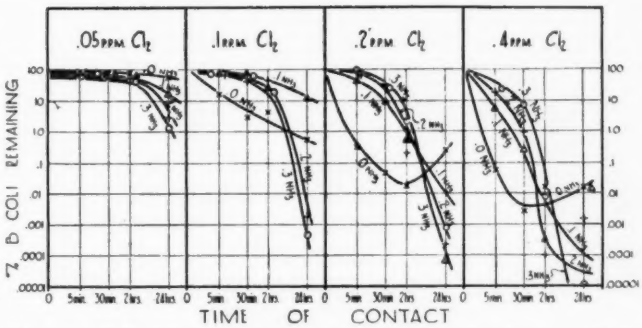


Fig. 1—Effect of Variation of Time of Contact on Bactericidal Efficiency of Ammonia-Chlorine Treatment; Chlorine Applied Constant (Experiment Series "A")

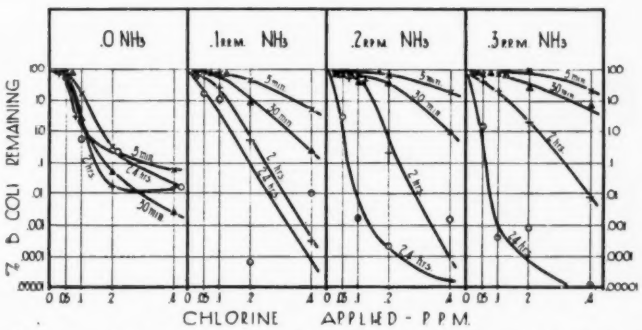


Fig. 2—Effect of Variation of Chlorine Applied on Bactericidal Efficiency of Ammonia-Chlorine Treatment; Ammonia Applied Constant (Experiment Series "A")

represents the normal temperature variation in the Chicago water supply. After a 5-minute contact there is very little difference in bactericidial effect, due to temperature. However, after 30 minutes' contact the higher temperature shows a greater efficiency, and after a 2-hour contact the increased efficiency due to the higher temperature is quite pronounced.

Effect of Turbidity.—An increase in the turbidity of the water decreases the bactericidal efficiency of the ammonia-chlorine treatment. In Table III are summaries of the bactericidal velocities obtained with the application of 0.2 p.p.m. of ammonia and 0.4 p.p.m. chlorine under similar temperature conditions. In experimental series A, B and C in which the average turbidity varied from 5.6 p.p.m. to 10.4 p.p.m., the percentage of B. coli remaining after 30-minute contact varied from 0.20 to 0.99 per cent. In experiment series D with the water having an average turbidity of 55.0 p.p.m. there was 15.4 per cent of B. coli remaining after a 30-minute contact. A similar decrease in efficiency with increased turbidity was observed in a study recently made by the writer of data obtained during five years of chlorination at Chicago.[3]

Effect of Increasing Chlorine Dosage.—As is to be expected, increasing the ratio of chlorine to ammonia increases the bactericidal velocity (as indicated in Fig. 4). In this experimental series the ammonia applied was kept constant at 0.2 p.p.m. and the chlorine varied from 0.2 p.p.m. to 2.0 p.p.m. A control with 0.4 p.p.m. of chlorine and 0 ammonia was included. The waters used were more turbid than those used in other experiments, the average turbidity being 55 p.p.m., the maximum 96 p.p.m. and the minimum 26 p.p.m. The work was carried out at room temperature. Each test was repeated four times. From this chart we find

[3] Gerstein Jour. A. W. W. A. Vol. 23, No. 1, Jan., 1931.

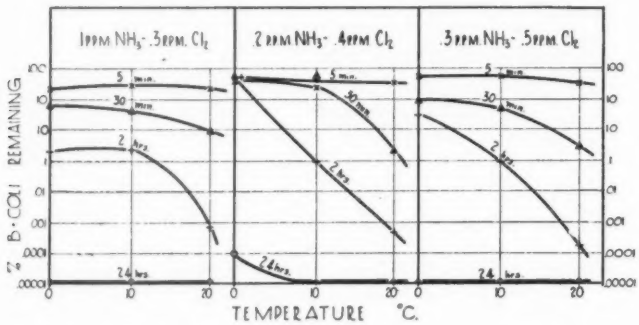


Fig. 3—Effect of Variation of Temperature on Bactericidal Efficiency of Ammonia-Chlorine Treatment (Experience Series "C")

that the combination of 0.9 p.p.m. chlorine and 0.2 p.p.m. ammonia has no greater bactericidal efficiency in 5 minutes than has 0.4 p.p.m. chlorine alone. The combination of 0.3 p.p.m. chlorine and 0.2 p.p.m. ammonia has the same efficiency after 24 hours contact as 0.4 p.p.m. chlorine alone. Unfortunately the combination of 0.9 p.p.m. chlorine and 0.2 p.p.m. ammonia did not prevent the formation of chlorophenol tastes. We must, therefore, come to the conclusion that the bactericidal velocity obtained after a 5-minute contact with the chlorine alone cannot be equalled by the use of any combination of ammonia and chlorine without the formation of tastes.

Persistence of Residual Chlorine.—The duration of the period in which residual chlorine (as shown by the ortho-tolidin test) persists in the water is greatly influenced by the amount of ammonia present and temperature of the water. Table IV shows the effect of temperature and ammonia on the persistence of residual chlorine on a highly turbid water, 104 p.p.m. turbidity. At 20° to 22° C. the residual chlorine persisted approximately 2 hours with 1 p.p.m. chlorine and no ammonia applied, whereas it persisted for 120 hours with the same chlorine dosage when 0.5 p.p.m. ammonia had been applied. At 0° to 2° C. a trace of residual was still present after 24 hours when chlorine alone was applied whereas with the addition of 0.5 p.p.m. ammonia and 1 p.p.m. chlorine there was 0.62 p.p.m. residual after 24 hours and as much as 0.2 p.p.m. residual after 22 days contact.

Control by Residual Chlorine Test.—Caution should be employed in using the residual chlorine test (shown by ortho-tolidin method) for controlling the ammonia-chlorine treatment. The same residual chlorine test may be obtained by using different ratios of ammonia

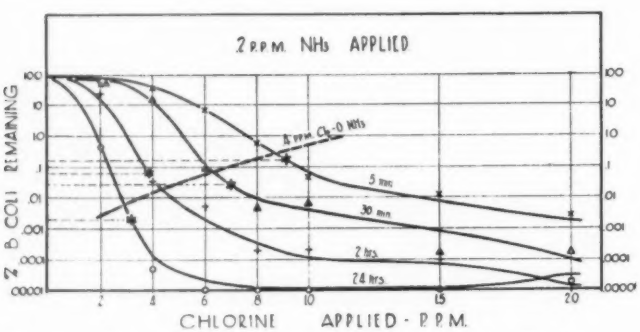


Fig. 4—Effect of Increasing of Chlorine Application on Bactericidal Efficiency of Ammonia-Chlorine Treatment; Ammonia Applied Constant (Experiment Series "D")

and chlorine, yet these various combinations of ammonia and chlorine may have widely varying bactericidal efficiencies. This is shown in the data in Table I. With 0.4 p.p.m. chlorine and 0.1 p.p.m. ammonia applied the residual chlorine test after 30 minutes contact was 0.34 p.p.m. and there was only 0.26 per cent of the B. coli remaining. With the same chlorine dosage and 0.3 p.p.m. ammonia applied the residual test after the same period of contact has practically the same—0.35 p.p.m., but there was 6.8 per cent of the B. coli remaining. Without ammonia, 0.19 p.p.m. residual chlorine after 30 minutes contact left but 0.003 per cent B. coli remaining, whereas with 0.3 p.p.m. ammonia applied the same chlorine dosage showed 0.35 p.p.m. residual but 6.8 per cent of the coli remained alive. It is apparent that with the ammonia treatment higher residual chlorine values should be carried as a general rule.

Conclusions.—Following are the conclusions drawn from the data presented in this paper. These conclusion concern only the results obtained by the use of ammonia-chlorine treatment on Lake Michigan water having a hydrogen-ion concentration of 7.8 to 8.0.

1. The treatment is effective in preventing the formation of the chlorinous and chlorophenol tastes and odors which are associated with the chlorination of water supplies, and is in addition a very efficient bactercidal agent where adequate contact is available.

2. For the same chlorine dosage the bactericidal velocity of the ammonia-chlorine treatment is decidedly slower during the first two hours after the treatment is applied than that obtained with chlorine alone. The larger the amount of ammonia present, the greater the lag in bactericidal effect.

3. For periods of contact longer than two hours the bactericidal effect of ammonia-chlorine treatment is greater than that obtained by the use of the same amount of chlorine alone. In this period the ultimate effect is greater with a larger amount of ammonia present.

4. By increasing the ratio of chlorine to ammonia it is possible to obtain a combination which will equal the bactericidal efficiency attained after a 5-minute contact when using chlorine without ammonia. This ratio of chlorine and ammonia, however, did not prevent the formation of chlorophenal tastes and odors in the Chicago water.

5. The temperature of the water has a marked effect on bactericidal efficiency of the treatment, the efficiency decreasing with lowering of temperature within the range of the experimental work 20° to 0° C.

6. An increase in the turbidity of the water materially decreases the bactericidal efficiency of the ammonia-chlorine process.

Acknowledgment.—The foregoing is a condensation of a paper presented May 27 at the convention of the American Water Works Association.

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GOOD ATTENDANCE AT NEW JERSEY SEWAGE SHORT COURSE.—The short course for sewage plant operators conducted May 2-14 at Rutgers University, New Brunswick, N. J., was attended by 31 men. Of these 20 were operators of sewage disposal plants in New Jersey.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

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REAL PROGRESS BEING MADE IN TREATMENT OF WATER TO PREVENT CORROSION

THE symposium on treatment of water to prevent corrosion at the Pittsburgh convention of the American Water Works Association last May is an indication of increased interest in this important subject. It is very gratifying to know that real progress is being made, and while it is much slower than some of us predicted a few years ago, it is evident that the treatment of water to prevent corrosion is eventually going to be extended to most of the corrosive waters.

The following are some of the reasons why progress has been slow:

1. Lack of agreement until recently as to how corrosion takes place.
2. The theories of corrosion at first confused those attempting to treat water to prevent corrosion.
3. A few are still hoping that a cheap non-corrosive metal will be found.
4. Many still believe that the manufacturer will eventually be able to apply a permanent protective coating.
5. Fear of complaints if the water is hardened.
6. Indifference to the need for preventing corrosion.

Lack of General Agreement Until Recently as to How Corrosion Takes Place.—At first there was the theory of simple oxidation, but this was soon given up when it was found that liquid water was essential for corrosion to take place. Crace Calvert[1] is usually credited with being the first to suggest that an acid was necessary for corrosion to take place. This theory was accepted without challenge until 1903, when Whitney[2] proposed the electrochemical theory of corrosion. According to the electrochemical theory the presence of an acid is not necessary to produce corrosion of iron. Considerable attention was given to corrosion over 20 years ago, and several excellent articles supporting the electrochemical theory of corrosion of iron were published. Dr. William H. Walker[3] took the leading part in advocating this theory, and published several articles. These articles discussed very fully the electrochemical process of corrosion and the part that dissolved oxygen plays in under-water corrosion. He suggested that corrosion in boilers could be prevented by removing the dissolved oxygen from water.

Fuller[4] states that: "Whitney started the electrochemical theory on lines which are predicated on the assumption that pure iron up to certain limits will pass into solution when placed in pure water. This is conceded now to be correct and that iron will dissolve in pure water, independently of any other constituent generally found in natural waters." Many accepted the electrochemical theory of corrosion of iron between 1903 and 1910, but apparently many did not, for Friend[5] in the 1911 edition of his book on corrosion of iron and steel gave considerable space to attempting to prove that an acid was necessary for corrosion to take place. This is interesting in view of the now generally accepted electrochemical theory. Other theories have been advanced by various writers, but none of them have gained much recognition. The acid theory gained such wide acceptance years ago that it was some time before the electrochemical theory became widely accepted. In fact it was not until about 1923 to 1925 that sufficient data were available to convince most every one that the reaction is electrochemical.

Theories of Corrosion Tend to Confuse Those Attempting to Treat Water to Prevent Corrosion.—From 1922 to 1925 there appeared a number of excellent articles on corrosion, which furnished ample proof of the correctness of the electrochemical theory. Some of the leading articles relating to corrosion under water were by McKay[6], Wilson[7], Bancroft[8], Evans[9], Whitman, Russell and Altieri[10], and Shipley, McHaffie and Clare[11]. In the attempt of some of these authors to thoroughly establish the electrochemical theory of corrosion of iron, considerable stress was placed upon the fact that the hydrogen ion concentration of the water between pH of about 5.0 and 9.5 had no appreciable effect upon the initial corrosion rate of iron and steel.

Naturally this was interpreted by many to mean that it did no good to treat water to prevent corrosion. It may have been excellent data to substantiate the electrochemical theory of corrosion, but it greatly confused those treating their water to prevent corrosion, or those giving serious consideration to the treatment of their water for this purpose. For a while it was difficult to induce others to treat their water. The theory was all right, but it applied to conditions that do not exist to any material extent in water pipes. Even to this date some of the articles are misleading. At the time of this writing a paper was presented by Groesbeck and Waldron[12] before the American Society for Testing Materials, June 25, at the Chicago convention, on "Oxygen as a Factor in Submerged Corrosion." The article gives excellent information on initial corrosion rates, but it may be misleading to those who are consid-

ering the treatment of their water to prevent corrosion. The authors state: "It has been shown (referring to the work of Whitman), that variations in the hydrogen-ion concentration of the corroding liquid, within the range from pH 9.5 to 4.5, do not change the corrosion rate, since the liquid film adjacent to the metal maintains a constant pH value because of the solubility of ferrous hydroxide, and hence acts as a protective film. The rate of corrosion in natural waters is determined by the speed at which oxygen diffuses to the cathode area and by the degree of protection which the resultant film offers. Therefore the extent of corrosion of iron in a natural water depends upon the concentration of dissolved oxygen. A protective rust film builds up on the iron with continued exposure." If the authors of such articles would state that the data have no bearing upon corrosion prevention treatments in public water supplies they would not make it so difficult for those striving to reduce the enormous wastage of iron pipes in public water supplies by treatment of the water. It is neither practical nor desirable to remove the dissolved oxygen from a water supply. If water contains little or no dissolved oxygen, it should, in most instances, be aerated to restore the dissolved oxygen.

A Cheap Non-Corrosive Metal Not Likely to Be Developed.—There probably are a few who still hope that a cheap non-corrosive metal will be perfected. Considerable progress has been made in the development of corrosion resisting ferrous alloys, but the price at the present time is so high they do not offer much encouragement as a substitute for iron water mains. Red brass, containing about 85 per cent copper, is making some progress in replacing galvanized iron for service pipes where the water is corrosive. It is likely that cast iron will continue to be the most extensively used material for water mains for many years to come, and if there is to be an improvement in lessening corrosion in the near future it will have to be by the application of more durable coatings by the manufacturer, or by the treatment of the water to make it non-corrosive by the water works.

Coatings Applied by the Manufacturer Not Permanent.—Some progress has been made in the application of more durable coatings. It is believed that the cement linings now being applied are a distinct improvement over the tar coatings which have been used so extensively. The lining of water pipes by cement was patented by Jonathan Ball in 1843. The early methods of lining pipes with cement apparently were not entirely successful. A committee of the city council of Springfield, Mass., sent a series of questions in regards to the use of cement lined pipes to 50 towns and cities in 1888[11]. There were 40 replies, and the majority stated that the use of cement lined pipe was in disfavor and that it was rapidly being replaced. Brookline used cement lined pipe between 1859 and 1884, and had given it up. Chelsea, Mass., used cement lined pipe for 21 years, and its condition was fairly good. Worcester had a little of the pipe in use for 12 to 16 years, but the condition was poor due to frequent leaks. The article gives the experience of a number of other cities with cement lined pipe. Examination of some of the cement lined pipes laid in Danvers, Mass., in 1876, and removed about 3 years ago indicate that cement lining properly applied has a very long life.

The writer believes that the present tendency is to apply cement linings too thin, though a much better lining is being applied than 50 to 75 years ago. This is going to result in some of the recently cement lined pipe, where exposed to corrosive water, corroding much earlier than is expected. This should not discourage the use of cement linings, for it is likely the most durable lining that can be applied at a reasonable cost at the present time.

Should an absolutely permanent lining be developed, there are still many million dollars worth of iron pipes already in service that do not have a permanent lining. It seems very unwise, therefore, to delay treating the water to prevent corrosion with the hope that a permanent coating can be applied by the manufacturer. Treatment of the water is something that may be stopped at any time non-corrosive metals are substituted.

Fear of Complaints if the Water Is Hardened.—The thing which has been most responsible for the delay in treating water to prevent corrosion has been fear on the part of water works officials that the treatment will produce complaints. It is almost impossible to convince some officials that proper treatment of the water will materially lessen complaints instead of increasing them, yet it is a fact. The responsibility for not treating corrosive waters to lessen corrosion should now rest squarely upon the shoulders of the officials in charge, for there is ample evidence of its benefit both in protecting the pipes and producing a more desirable water. The opposition that water works officials would encounter from the public is negligible in practically all instances. Let some city that has been treating their water for several years to prevent corrosion stop the treatment for a while and see what happens. In nearly all instances where this has been tried complaints have become so numerous that the water department has had to return to some kind of treatment to lessen corrosion. Now this is not saying that any kind of corrosion-prevention treatment will be free from complaints. Several years ago the writer was asked to investigate a certain water that was being treated with lime to prevent corrosion. The lime was being applied so irregularly that the water going to the mains was caustic part of the time. Naturally this gave the water a caustic lime taste. Proper control of the lime application eliminated all this trouble, and the superintendent of this water works recently told the writer that there have been no further complaints.

Indifference to the Need for Preventing Corrosion.—Indifference to the need for preventing corrosion is responsible for many waters not being treated. The majority of the water works officials are striving very hard to furnish the consumers pure and palatable water. The purity is demanded by health officials and the palatableness is demanded by the consumers. Unfortunately many of our officials who are alert to see that these demands are met give other matters little consideration. The value of these factors is not underestimated, yet they are not all that go to make a perfect water supply. Much of the indifference to the chemical qualities of the water is due to the fact that the management of nearly all water supplies are engineers, practical water superintendents, and in a few instances politicians. Naturally they wish to avoid as much chemical treatment as possible and are frequently indifferent to or do not seek competent chemical advice.

All of the responsibility for lack of chemical treatment to prevent corrosion, however, does not rest upon the superintendents, for the chemists in a number of the treatment plants have a free hand to treat the water as they think best. Frequently the chemist has little or no knowledge of what the water is doing to the pipes in the distribution system and is not aware that the water is corroding them. We sometimes find the various divisions of a large water department very efficient

in the operation of their own part of the works but quite indifferent to the problems of the other divisions. The filtration engineer should be more concerned about clogged pipes and leaky pipes due to corrosion than the distribution engineer whose duty it is to unstop the clogged pipes and repair the leaks.

These constitute some of the reasons why progress in the treatment of water to prevent corrosion has been slow. Now let us review some of the things that have been accomplished, for treatment to prevent corrosion, even though slow in being adopted, is bound to come. It constitutes the only hope of greatly lessening the enormous wastage due to corrosion of pipes in water systems.

Early Use of Alkalies to Reduce Corrosion.—It is difficult to state when alkali was first used to reduce the corrosiveness of water. We have records of the use of soda ash or lime almost from the very beginning of the coagulation of water with aluminum sulfate. The early uses of an alkali were to make up the deficient alkalinity so as to get a good coagulation and little or no thought was given to the prevention of corrosion. Such treatments, however, did some good, and very likely in some instances much more alkali was added than was necessary for the chemical reaction, so as to reduce red water troubles. The first record of the use of lime primarily to prevent corrosion, which the writer has found, is an article by Smith and Chaplin in 1904[14]. The treatment was recommended by Dr. Percy Frankland, and was for preventing corrosion of lead pipes. "Finally it was decided to treat the water with 1 grain of chalk before filtration and add limewater afterwards. At first the lime used was at a rate of 4 grains per gallon, but was subsequently reduced to 1 grain. This method has been in vogue since the middle of July, 1903." The lime was added in the form of clear limewater, and as it was added after filtration it is evident that its use was promarily to prevent corrosion.

Fuller[4], in 1910, makes the following statement: "For years the acid qualities of upland or moorland waters of Great Britain have been treated with lime or soda to remove their acid qualities in order to minimize or reduce their corrosive action. It is not the purpose of this article to attempt to detail why the new water supply from the Welsh mountains for the city of Birmingham, is best treated with lime, or why the city of Wakefield, England, prefers to treat its supply with soda, to minimize corrosive action. It is desired to point out very clearly that preventive and corrective measures are capable of application on lines proportional to their needs."

The writer used lime primarily to reduce corrosion at Jackson, Miss., in 1915 and 1916[15], applying the lime to the settled coagulated water before filtration most of the time. The water was treated to where there was a slight monocarbonate alkalinity, which would be a pH of about 8.3 to 8.5. All complaints of red water ceased and the treatment seemed to be entirely satisfactory to the consumers. At least no objections were raised by any one. It is understood that the amount of lime was materially reduced after the writer left Jackson, and that there has been some trouble from red water since 1916.

Lime was added to the water in the settling basins at Panama in the latter part of 1916 to reduce the free carbonic acid, according to a report by Bunker[16]. From Dec. 2, 1916, to the end of the year (fiscal year ended June 30, 1917) carbonate alkalinity was present continuously in the effluent from the settling basins.

Lime exclusively for the prevention of corrosion was started in Baltimore in 1919[17]. At first it was applied to the water after coagulation and sedimentation, but before filtration. Soon the point of application was changed to the filtered water, where it has been applied continuously up to the present time. Hechmer started applying lime to the filtered water at Hyattsville, Md., in 1923.

Protective Film Is the Only Way Corrosion of Iron Can Be Stopped.—It has been most difficult to convince many water works officials that the only way iron may be prevented from being corroded when exposed to water suitable for domestic uses is by a protective film. If we think of iron, lead and zinc as being soluble in water, then it is easy to understand why a protective film is absolutely necessary for long life of pipes. It is true that these metals do not go into solution so rapidly as a lump of sodium chloride or some other fairly soluble salt, and the process of going into solution may be different, but it is a good plan to think of the metals being soluble as though it was the same process.

The writer has repeatedly warned that it is essential for the manufacturer to put on a very durable coating, and that good protection can then be obtained only by the use of treatments that tend to build up a slight film. It is not desirable to use a treatment that builds up a film rapidly, for it might eventually become thick enough to give trouble. Fuller[4] referred to films formed by turbid water as offering considerable protection to the pipes. "The majority of the surface waters, particularly those that are muddy or highly colored, seem to have the faculty of forming deposits or coatings on the inner surface of pipes in a way to lessen the corrosive action. Such coatings also seem to retard the rapidity of the corrosion after it once gets under way by forming a film at the point of attack, sometimes spoken of as resembling the 'closing of a wound.' Softened waters and waters where iron and lime treatment is used, do not seem to corrode so rapidly as when acid is present. Filtration removes the turbidity, and this aids in making the water more corrosive."

A review of the literature on treatments to prevent corrosion indicates that a few realize the importance of protective films whereas others do not seem to give it much consideration.

The Literature on Treatments to Reduce Corrosion.—An editorial in *Engineering Record* in 1909[18], on the red water plague, refers to the fact that alum treated waters are more corrosive than the natural water, and states that this is probably due to an increase in the CO_2. The reference by Fuller to the film formed by turbid water indicates that not only does the increase in CO_2 aid in producing corrosion, but the removal of suspended matter prevents the formation of a protective film by the suspended matter. The editorial states that alum has its red water problem, iron and lime has its problem of incrustation, so also has the use of soda and lime for water softening. In the iron and lime treatment, and in softening, the water is treated to where a film is formed more rapidly than is desired. The soda and lime treatment for softening has been used for years, and the iron and lime treatment has been used since about 1903. The protective value of the films formed by these treatments was recognized shortly after the beginning of such treatments. The trouble was with the films being formed too thick. Now by the addition of CO_2 to waters treated with lime, the thickness of the film is being controlled in some water supplies.

Monfort[19] in discussing the action of the St. Louis water on metals and alloys says that a protective coating is formed on the surfaces exposed, and also that the

hydroxyl ions largely inhibit corrosion of iron. Dissolved saline matter increases the conductivity of the solution and accelerates the corrosion of zinc. Treatment of the St. Louis water with lime and iron was started in 1904.

The writer[17] in 1922, described the treatment given the Baltimore water. The article states that since October, 1919, lime to reduce corrosion has been used almost continuously. "The application of lime after filtration as is now being done, to give a pH between 8.5 and 9, requires about 0.55 grain per gallon, costing about $35.00 per day." The water treated averaged about 100 million gallons daily, so the cost was approximately $0.35 per million gallons.

M. C. Whipple[20] describes the use of soda ash at Cambridge, Mass. The pH of the treated water in the filtration plant was 6.1 to 6.2. After the addition of the soda ash the pH was increased to 6.6 to 6.9 and the CO_2 reduced to about 4 ppm. The quantity of soda ash used varied between 80 and 140 lb. per million gallons. Lime would be cheaper, but it was desired not to harden the water. In cold weather it was found that a pH of 6.8 to 7.0 held corrosion within satisfactory limits. Whipple and Chandler[21] later report that the pH of the final effluent averaged 6.95, and that the treatment produced fairly good results.

More Specific Information on Treatments Necessary to Prevent Corrosion.—In 1926, the writer[22] discussed factors influencing the corrosion of iron pipes. This article gave a curve showing the approximate solubility equilibrium of calcium carbonate, and the relation of the solubility of iron salts and ferrous hydroxide to this curve. It was shown that no appreciable amount of iron could remain in solution in the water when it was saturated with calcium carbonate, the actual amount being less than 0.1 part per million of iron. At a pH of 6.5, over 20 parts per million of Fe as ferrous carbonate might be found in solution in the absence of dissolved oxygen, and the amount of iron salts increased quite rapidly below this pH. This article also explained the formation of pits with overlying tubercles.

Again in 1926, the writer[23] published an article on the prevention of corrosion and red water. This article dealt more extensively with the factors influencing the corrosion of pipes, and discussed somewhat fully the desirable treatments to prevent corrosion of the several metals used for water pipes. It was shown that the prevention of corrosion depended almost entirely upon protective films, whether applied by the manufacturer or built up from constituents in the water. The relation of the calcium carbonate solubility to the prevention of corrosion was discussed more fully than in previous articles. It was stated that iron pipe without a protective coating of zinc or some durable paint should not be exposed to any of our natural waters. It is possible to form impervious films which eventually stop corrosion, but not until considerable tuberculation has taken place and the pipes reduced in carrying capacity.

Laux[24] gives the causes and methods of preventing red water. The prime factors in corrosion are hydrogen ion concentration and dissolved oxygen. The protective rust film formed is less stable in acid than in alkaline waters. CO_2 increases the ionized hydrogen in the water and weakens any protective coating of iron rust. The addition of lime converts the bicarbonates to normal carbonates, which deposits a fine coating of calcium carbonate on the pipes and protects the iron from the water. Lime is added to the water after filtration at Akron, O., and has eliminated all red water troubles. At Evansville, Ind., the lime is added just before filtration.

Troubles from red water at Southern Pines, N. C. started shortly after completion of the new supply in 1925. This is described by Butler[25]. The marble test indicated that the saturation point of calcium carbonate was at pH of 8.4 to 8.6. Lime was added to give the water a pH of about 8.4 to 8.6. Le Bosquet in discussing the paper stated that in December, 1926, the trouble returned. Lime was added to the filtered water to increase the pH from 6.2 to 8.4, but the corrosiveness was unchanged. Larger quantities of lime were used, and it was found that 17 ppm. of lime reduced the corrosion to where it would not produce trouble. This treatment gave a pH of about 9.8 and alkalinity of 21. Le Bosquet experimented with sodium silicate in the laboratory and recommended its use in connection with lime. Catlett in discussing Butler's paper stated that very good results in the elimination of red water were obtained at Fayetteville by the use of lime. The calcium carbonate equilibrium according to the marble test was at pH of 8.8. The water was treated to a pH of 9.5. Norcom stated that a secondary lime treatment had just been started at Charlotte.

The writer in 1927[26], stated that no treatment of water will prevent corrosion of iron when a fresh metal surface is exposed. Water at the solubility equilibrium of calcium carbonate, and containing over 25 ppm. of calcium carbonate will precipitate calcite where corrosion takes place, and this aids in the formation of an impervious film. Where the water has less than 25 parts per million of calcium carbonate, lime should be used for the protection from corrosion, and where there is more than this amount either lime or soda may be used, though lime is much cheaper than soda.

A de-acidification plant consisting of aeration by means of spraying and then filtering through a marble filter has been described[27]. The filter consists of a layer of large grain marble and an upper layer of fine marble. It is 1.50 meters in height. The rate of filtration is 1.25 meters per hour. One square meter of the filter de-acidifies 30 cubic meters of water per day. The de-acidification reduced the free carbonic acid from 48 to 5 ppm. and increases the total hardness from 1.8 to 5.0 degrees.

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(To be continued in the September issue)

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Municipal Water Softening In Kansas

An interesting review of municipal water softening practice in Kansas was given by R. E. Lawrence, Assistant Engineer, Kansas State Board of Health, in a paper presented at the 9th annual water works school at the University of Kansas. The notes following are taken from his paper:

At the present time approximately half of the population of Kansas, living in 327 cities, are served by public water systems. Of the total 327 supplies, only 54 are classified as surface supplies, being obtained from streams or impounding reservoirs. However, it is interesting to note that approximately half of the population served by public systems are supplied by these 54 surface supplies.

Generally speaking, there is little difference in hardness between the surface waters and the ground waters of Kansas. In a few instances surface supplies which are obtained from impounding reservoirs having favorable drainage areas are appreciably softer than those obtained from streams. This is particularly true in the case of the Yates Center and Pleasanton supplies. Among the ground waters, Baldwin, Wellsville, Conway Springs and a few others have waters containing a comparatively low content of the dissolved minerals which cause hardness. Chemical analysis of the 327 city supplies, however, indicate wide variations in total hardness. The variations range from a total of 26 p. p. m. hardness as calcium carbonate, to a total hardness of over 1000 p. p. m. Gottlieb shows that the average hardness of all Kansas supplies is 334 p. p. m., the mean for the ground waters being 342 p. p. m., and for the surface waters 318 p. p. m.

If the arbitrary limit of 100 p. p. m. hardness is selected as the line of demarkation between soft and hard water, Kansas supplies are for the most part very definitely on the hard water side. In fact, Gottlieb further shows that only eleven supplies have a total hardness of less than 100 p. p. m., and that these serve less than 2 per cent of the total population supplied. Kansas is therefore essentially a hard water state.

Municipal water softening in Kansas has to date been confined, for the most part, to the removal of carbonate hardness by lime treatment. In no instance has an attempt been made to reduce the total hardness to less than 100 p. p. m. Recently, soda ash treatment for the removal of non-carbonate hardness has been included at two plants, and we can expect more attention to the removal of non-carbonate hardness in future installations. Lawrence, Topeka, Manhattan, Iola, Marion, and Lincoln are softening at the present time. The new plant at Neodesha, now under construction, will soon be added to this list. The large number of filtration plants that use lime as an aid to coagulation and accomplish a small amount of softening incidentally, are not taken into consideration. In order to review municipal softening practice, it will be necessary to discuss briefly the operation at a few of the plants engaged in softening.

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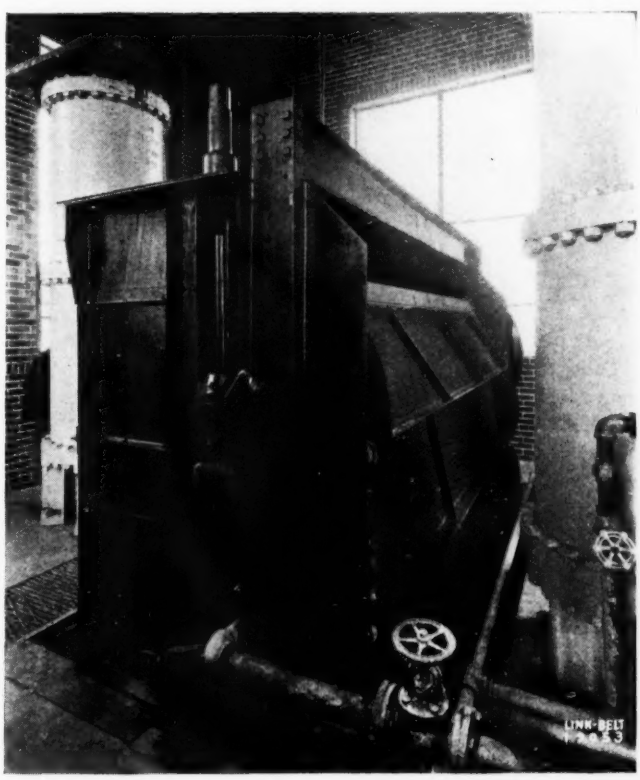

Wide Water Screen at St. Louis

What is believed to be the two widest water screens in the world are installed at the Chain of Rocks Pumping Station of the City of St. Louis, Mo. They are Link-Belt traveling water screens, each being 125 in. wide and 56 ft. 6 in. centers.

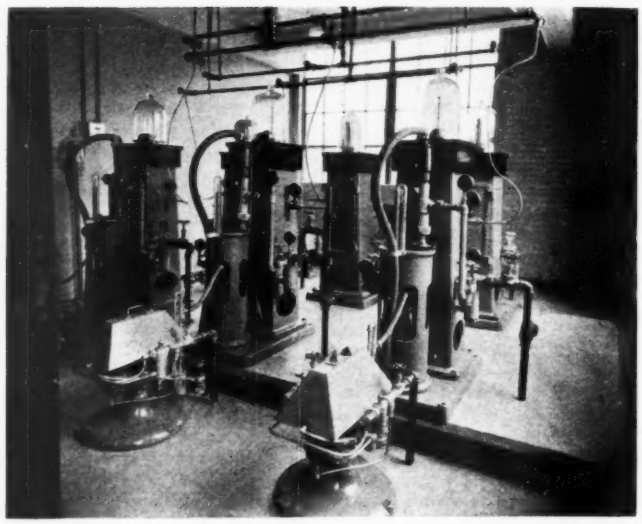

Fig. 2—Automatic Chlorinators, Raymond Dam, Wanaque Reservoir

OPERATION OF WANAQUE RESERVOIR OF NORTH JERSEY WATER SUPPLY DISTRICT

By ATTMORE E. GRIFFIN

Analyst in charge of Wanaque Laboratory, North Jersey District Water Supply Commission

THE operation of Wanaque Reservoir located in northern New Jersey is not radically different from others of similar size and character. Chlorine, lime, copper sulphate and aeration are used here as elsewhere, perhaps in slightly different proportions but with the same final effect.

Chlorine is now and probably always will be added continuously. Lime has been added since September, 1930. Copper sulphate is used as the necessity arises and aeration is employed during the spring and fall "turnovers."

Laboratory Studies.—The control of these various processes are vested in the laboratory which is directly responsible for the quality of the water. In addition, the laboratory is studying the quality of water at different reservoir depths at different times of the year, the relative quality of the water entering the resrvoir, the influence of manganese or other substances on the ortho-tolidine test for chlorine, the effect of this new water on the old mains in the communities served, and other problems as they arise. The laboratory also makes daily examinations of the raw and delivered water for bacteria, color, microscopical organisms, etc., as part of the control in connection with chlorination and "limation."*

Chlorination.—The reservoir, Fig 1, holding some twenty-seven billion gallons of water depends primarily on storage for purification. The efficiency of this storage is shown by the fact that during the greater part of the time the water would meet the Revised U. S. Treasury Department Standard for drinking water without chlorination. However, it is the practice to

"Limation."—A word, coined by the author to signify lime addition to the water to increase its pH value and reduce its aggressiveness for pipe line corrosion prevention. It bears the same relation to lime application as does chlorination to the application of chlorine.—Editor.

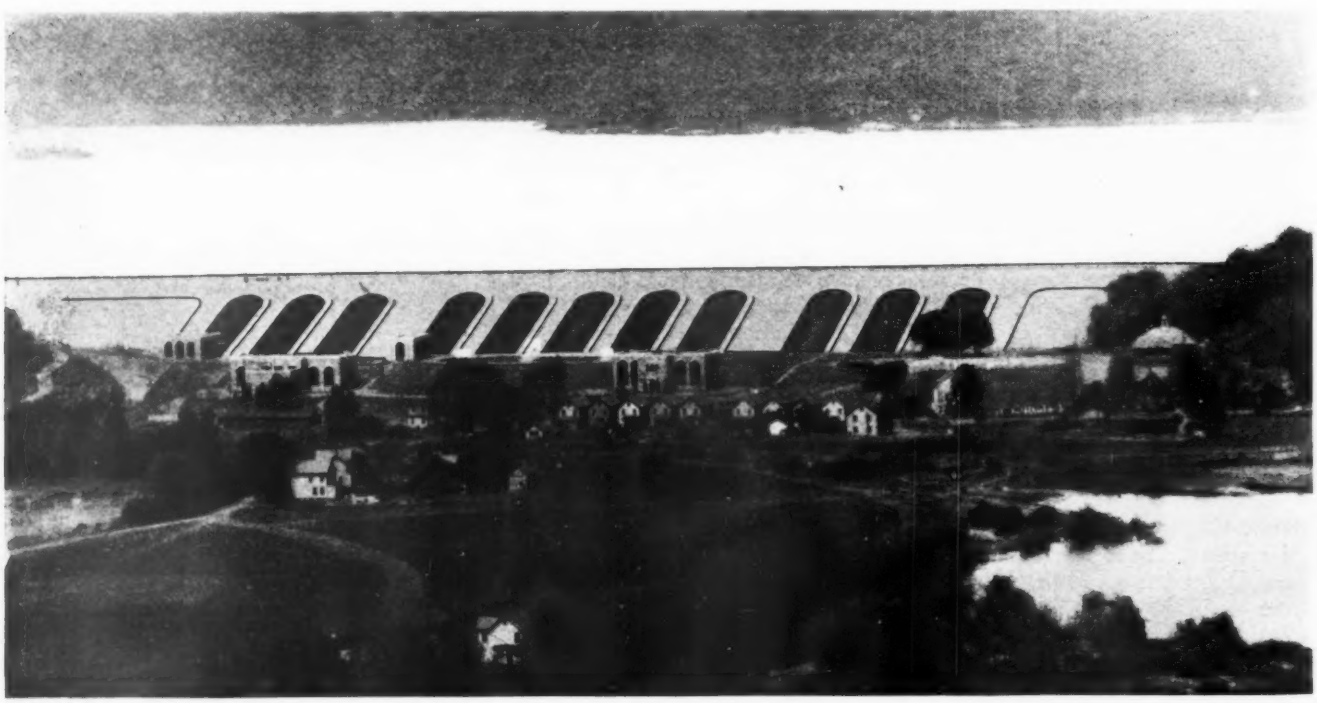

Fig. 1—Raymond Dam; Wanaque Reservoir in Background. The Building at Front of Dam at Left End Is the Control and Chlorination House; Small Building at Left of Aerator Is Aerator Control House; Large Structure at Right and in Front of Aerator Is Administration Building, and Large Structure at Left of Aerator is Pumping Station

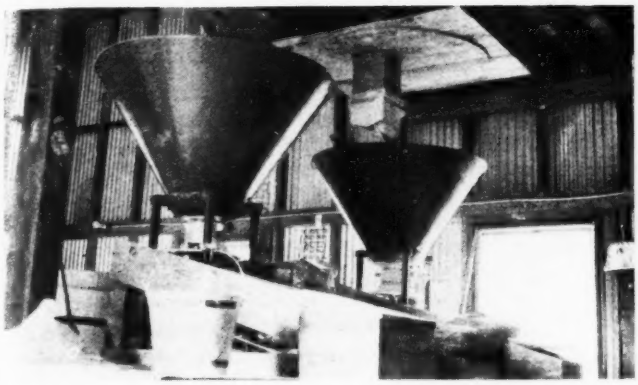

Fig. 3—Line Feeders in Lime House Just Below Reservoir

continuously add chlorine as the water enters the aqueduct in sufficient quantity to maintain not less than 0.10 P.P.M. residual chlorine at the end of a 30 minute contact period. In determining residual chlorine in the Wanaque water it is frequently necessary to deduct from the apparent chlorine value a "blank"—i.e. false residual chlorine value—which seems to be caused by manganese present in the raw-water.

The residual chlorine is checked each hour at a point approximately 1700 ft. below the chlorinators. To insure the ½ hour contact, the operator holds the sample a certain definite period, depending upon the rate of flow at the time of sampling, before adding the orthotolidine. The addition of chlorine not only kills any bacteria that survive the storage but also improves the taste of the water by neutralizing many tastes produced by algae growths. We have learned that tastes are usually more effectively destroyed by increasing the chlorine than by reducing it.

Vacuum type automatic chlorinators, Fig. 2, are employed for applying the chlorine. Water is furnished to these machines by centrifugal pumps driven by water turbines. The water used for power is part of the water required by legal agreement to be discharged into the stream. Standby units consisting of electrically operated pumps furnish operating water in emergencies. As a further safeguard there is installed in the upper gate house, two manually controlled vacuum type machines. These have three sources of water, namely, an electric pump, a gasoline pump, and the general service water turbine pumps.

Application of Lime.—Nineteen hundred feet below the intake to the conduits hydrated-lime is added to the water. Two dry feed machines, Fig. 3, apply lime to a mixing and equallizing tank. The lime suspension in this tank is diluted and kept in circulation by a tangential water inlet at the bottom and from it is pumped into the mains, Fig. 4, against the reservoir head. Hydrated lime is supplied on specification in 50 lb. paper bags and is handled at the treating station by belt conveyor equipment. To date from 4 to 15 P.P.M. lime has been added to maintain a hydrogen ion value of around 8.0. The flows in the aqueduct vary so greatly that it has been very difficult to maintain a constant pH value. To remedy this difficulty we expect to install an automatic pH recorder and lime dose adjuster.

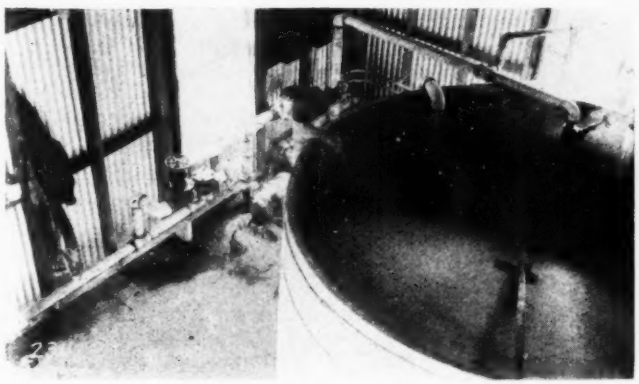

Fig. 4—Lime Suspension Tank and Centrifugal Pumps Injecting Lime

Aerators have been provided at the headworks, large enough to take care of a maximum flow of 150 M.G.D. Since the use of these necessitates pumping, they are used only when essential. It is expected that aeration will be practiced chiefly during the fall "turnovers" when odors and tastes are most noticeable.

Treatment for Algae Troubles.—Plankton abounds during the whole year, especially in the upper 20 ft. of water. During the spring and fall overturns these organisms become thoroughly mixed through the whole reservoir. So far it has been the practice to avoid algae troubles by drawing water from an intermediate intake 40 ft. below the surface. Water from this level has the advantage also of being very cool. As the summer progresses, however, and biological forces approach their climax, (usually late August or early September), the surface water is treated with copper sulphate. This treatment kills the annoying microscopical organisms and produces a layer of water which is more acceptable than the lower stratas impregnated with gases and odors which accumulate in the lower layers of this new and deep reservoir during the summer stratification period.

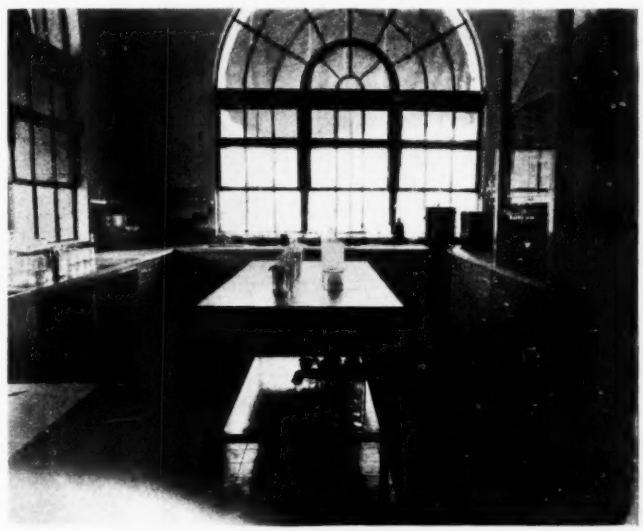

Fig. 5—Chemical Laboratory in Service Building at Raymond Dam

In addition to this major treatment all coves and lagoons are "coppered" whenever excessive algae growths occur. Copper sulphate applications tends to prevent seeding in the main body of water. The coves are not "coppered" when large numbers of rotifera or crustaceae are present because it is felt that with the help of these scavengers the water will become stabilized more thoroughly than by artificial means.

Sanitation Control.—The sanitation of the watershed is being very carefully controlled. Two men, under the direction of the laboratory, are patrolling it constantly. These men watch campers and hikers, keep in contact with the schools and local health officers, regularly inpect all property on the watershed, and make recommendations regarding the sanitation of potential

sources of pollution. Existing sources of direct or potential pollution are being rectified as rapidly as practicable. No attempt is made to stop bathing in waters tributary to the reservoir for a New Jersey law makes this legal. Bathing in the reservoir itself, however, is not allowed.

Fishing in the reservoir is prohibited principally for sanitary reasons. It is readily apparent to anyone who stops to consider the situation just what would happen should fishing be allowed. Situated as close as the Wanaque reservoir is to large centers of population, people from many communities would soon be roaming the shores. Many of these would not be careful of their habits, as repeated experiences have proven. It is relatively easy to control potential sources of pollution of a fixed population, but very hard indeed to control the sanitary habits of a moving one. The ruling against fishing is strictly enforced by guards who patrol the entire shore line during the daylight hours.

Some 300,000 seedlings were planted on the watershed about four years ago. Although a few have been damaged by fire the majority are flourishing. At the present time a comprehensive reforestation plan is being worked out for present and future use.

In conclusion it might be said that it is the aim of the commission and its employees to make the Wanaque system a model water works from its head waters in the mountains through to the consumers.

Acknowledgement.—The above paper was presented June 4 at the organization meeting of the New Jersey Water Works Association.

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Highly Purified Sewage Provides Active Stimulus for Algae Growth

Experimental work was conducted during the past year by the City of Baltimore and the State of Maryland to prevent algal growth in the Back River. In the recently issued 1930 report of the Bureau of Sanitary Engineering of the Maryland State Department of Health, Abel Wolman, chief engineer, comments on this work as follows:

At the head of Middle River unusually prolific growths of Elodea Candensis created objectionable odors by the decomposition of the tops of these grasses that formed large mats on the surface of the water. The Clathrocystis and Coelosphaerium types of algae growth were exceedingly prolific in Back River in the vicinity of the outfall of Baltimore city's sewage disposal plant, despite a great effort on the part of the city to retard the growth by systematic applications of copper sulphate.

The algae growth in this section of Back River probably presents one of the most difficult stream pollution problems in the state. Paradoxical as it may seem, the production of a highly purified sewage from Baltimore's sewage disposal plant provides the active stimulus to growth. For the past few years much study has been given to this problem. During the past year a carefully planned system of copper sulphate treatment failed to retard the growth. The cooperative work of the city and state was supplemented by an investigation by Dr. W. C. Purdy, planktonologist of the U. S. Public Health Service, invited to review the situation in the field by the state department of health. Dr. Purdy concluded that the abundant blue-green algal growth was largely a result of the discharge into Back River of 60 million gallons daily of the highly nitrified sewage effluent from Baltimore's sewage treatment plant. This sewage effluent carries into Back River large quantities of carbon dioxide and nitrogen compounds, particularly nitrates, both highly encouraging to heavy algal growth. The elimination of the treated effluent from Back River would probably constitute an effective remedy for the algal growth. Such a remedy, however, would involve the extension, at great expense, of the outfall line to a point below the mouth of Back River. Because of the large expenditure necessary this remedy seemed undesirable. The periodic use of algicides upon the algae-bearing water was suggested as a possible remedy, but not strongly advocated for the present due to the difficulties experienced in dosing approximately 4 or 5 square miles of the river, whose depth averages from 3 to 6 ft., with a tide of from 1½ to 2 ft. and a flood or ebb tide every 6 hours. Treatment of the effluent with chlorine to reduce the organic load in the effluent is to be inaugurated on an experimental scale.

Treatment of the effluent with lime to remove the free and half bound carbon dioxide, to check the algal growth in the river, seemed to offer a promising attack. Accordingly extensive experimental work was conducted by the city under Dr. Purdy's direction to determine the effect upon this type of algae of removing carbon dioxide and bicarbonates from the plant effluent by treatment with lime. Results of the experiments, however, showed conclusively that the dissolved organic matter, together with the high content of nitrates, in the sewage plant effluent provide sufficient suitable nutriment for bacteria, which is converted continuously by the latter into carbon dioxide and other substances of food value to plankton. This free carbon dioxide is not only available for immediate use by the algae, but its presence in excess immediately reverses the reaction obtained by lime upon free carbon dioxide and bicarbonates to produce more carbon dioxide and bicarbonates. Carbon dioxide is likewise continuously absorbed from the air, so that the removal of the carbon dioxide and bicarbonates without destruction of bacteria or exclusion of dissolved organic matter and nitrates, is futile for retarding the growth of algae or other chlorophyll bearing organisms.

The experiments of Sahib Raju in India, published in the *Indian Journal of Medical Research,* 11: 1057, (1924) show success in the destruction of algal growth by applications of sulphuric acid to destroy carbon dioxide and bicarbonates. This agent effects a simultaneous toxic destruction of bacteria. Dr. Purdy suggests that experimental work be continued, using sulphuric acid as an algicide. A continuation of experimental post-chlorination of sewage at the disposal plant and further trial of the toxic remedies by direct application to the river of various known algicides, such as copper sulphate and chlorine, are additional recommendations appearing in Dr. Purdy's report.

This experimental work as previously indicated is being conducted to provide a substitute for the costly alternative of extending the outfall three or more miles down stream.

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PUBLIC WATER SUPPLIES IN TENNESSEE.—According to the biennial report of the State Department of Public Health of Tennessee for the fiscal years 1927-1929, there were 153 public water supplies in the state of which 81 systems are municipally owned and 72 privately owned. Of the 153 water works, 67 employed no treatment, 42 had disinfection alone, 35 had complete rapid sand filtration plants including disinfection, one employed coagulation, sedimentation and disinfection, and eight had iron removal plants.

SYMPOSIUM OF PRACTICE

HOW FREQUENTLY SHOULD METERS BE READ AND BILL RENDERED

Cambridge, Mass.

All meters are read monthly; bills, however, are rendered quarterly. We find the monthly readings very satisfactory, as it enables us to check up on the use of water, and also to discover leaks. Wherever excess use over the previous month has been found, a notice is sent to the owner requesting him to have his fixtures repaired. In this way we save a considerable amount of water, and also save the property owners unnecessary expense.—T. W. Good, General Superintendent, Water Works.

Independence, (Mo.) Water Works Co.

We believe that, theoretically, all meter statements should be taken monthly at such a time that the bills for service can be in the hands of the customer on the first day of the month succeeding that in which service has been rendered. However, many monthly bills are so small as to make it expensive to read meters and render monthly statements; and, we have found it more convenient to render bills quarter yearly for such customers whose use of water is small. When the average amount used by a customer increases to a point that, in the opinion of the supervisor of customers accounts it will support the cost of monthly handling, this customer's account is placed in the list for monthly billing. This system has the objection that unsuspected leaks sometimes continue over a long period, when meters are read quarterly, resulting in complaints by customers of large bills; but, by and large, we have found the method satisfactory.—H. A. Gallagher, Manager, Indepence Water Works Co., Independence, Mo.

Struthers, Ohio

Meter reading practice at the Struthers Plant of the Ohio Water Service Co., is to read and bill the domestic or residence meters quarterly and the industrial meter or meters of large consumption monthly. The domestic meters are divided into three zones whereby one-third of the meters are read and billed every month, thereby spreading out the working load. It would seem advisable that meters registering large consumptions be read and billed at least monthly giving a more accurate record and check of meter performance and eliminating the possibility of discussions in connection with the service which might arise where the consumption is not checked more frequently than the 3-month period.—G. Taylor Evans, Manager, Struthers Plant, Ohio Water Service Co.

St. Louis County Water Co.

It is the practice of the St. Louis County Water Co. to read meters quarterly and send out the bill to the consumer about three days after the meter reading. We are now billing continuously; i.e., a certain number of meter readers are in the field all of the time, and have a schedule which provides for covering the entire number of meters in three months, so that each consumer's meter is read at 3-month intervals, the variation from the three months, at any time, being only due to the recurring three months occurring on Sunday or on a holiday. We have a comparatively few large manufacturing accounts which are read and billed monthly. It is our experience that for domestic consumption reading meters and billing quarterly reduces our expenses very materially, and is quite satisfactory. Of course, by reading and billing continuously, we maintain a minimum force of meter readers and billing clerks, who are able to work efficiently by reason of having the volume of work reasonably constant. We approve meter reading and billing of large accounts monthly on account of the possibility of large meters going out of commission in a 3-month period, in which case the amount to be estimated is a very considerable sum.—W. H. Hanby, President, St. Louis County Water Co., University City, St. Louis, Mo.

Regina, Saskatchewan

The meters are read monthly and bills rendered monthly. This system is preferred to less frequent readings as it keeps the department in closer touch with the consumer, giving us an opportunity to check and replace meters which might be becoming slow on account of long use and it also gives the department an opportunity to warn a customer of high unnecessary consumption due to some leaking fixture, of which the customer is perhaps not aware. From the city treasurer's standpoint I think there is also the benefit of having revenue coming in at the more frequent interval.—J. W. D. Farrell, Superintendent of Water Works, Regina, Sask., Canada.

Toronto, Ont.

All accounts for metered services are rendered quarterly. Meters on premises that normally have a consumption of less than a 100,000 gal. per quarter, are read quarterly. All other meters are read monthly.—H. Reburn, Deputy City Treasurer, Toronto, Ont.

Detroit, Mich.

This department reads its meters quarterly. However, this does not mean that all meters are read on approximately the same date. We have divided the city into three zones and each zone into twelve reading districts. Under this plan, while each account is billed quarterly, there is a constant and even flow of money coming to the department because of the various billing dates and due dates. Under the plan used in Detroit, every other day is a due date for a district. With nearly 275,000 meters in service it would not be feasible to read these meters monthly unless there were a large number of readers employed and at a prohibitive expense, if the low rate for water prevailing in Detroit

is considered. The prime advantage of monthly readings is the early securing of revenue for water produced. While the Detroit system does not bring the revenue as close to the production point as the monthly system, the Detroit system, however, produces a steady flow of income. The department sees no reason, in view of the success of this system, of making any change. It may be noted, that some cities bill only every six months, at the same time going to the expense of reading meters more frequently as a check. It seems to the writer that a reduction of the billing period in those cities would effect a considerable saving of money by making use of the check figures for billing purposes. —D. C. Grobbel, Acting Secretary, Department of Water Supply, Detroit, Mich.

New Haven Water Co.

We have been reading our domestic or household meters on the quarterly basis since 1922 and for some five years prior to that, our schedule called for reading every 45 days. Our industrial and larger meters are, of course, read every month. In detail our practice is as follows: We have about 25,000 meters which are read by a force of six readers,—four men walking routes, one man with car on the industrial, manholes and outlying districts, and one man with car on skip readings. The readers are given 100 slips each morning. For the year of 1930 the following figures may be of interest:

Number of calls made	103,318	
Skipped on first call	8,225	(7.9%)
Number of bills made	98,946	
Number of estimated bills made	1,733	(1.8%)
Prorated bills made	428	(0.4%)

As to bills, the meters read today are billed tomorrow. The estimated bills being sent out at the end of the month, thus giving the skipper man a chance for two or three calls before sending such bills. We find the above practice of handling our reading and billing is working quite satisfactorily.—R. B. Walsh, Assistant Treasurer, New Haven Water Co., New Haven, Conn.

Scarborough, Ont.

At the present time our water meters are read every two months in conjunction with our electric meters, the one man reading both meters at the same time. Up until about two years ago our water meters were read every three months and we found that the period was too long, due to people changing address so often and running up arrears, and also it made a longer period for meters that failed to register.—R. Harrison, Manager, Public Utilities Commission, Scarborough, Ont., Canada.

Quincy, Ill.

Our practice in the matter of reading meters and billing is as follows: While we have a few large consumers whose meters are read monthly and billed monthly, our general run of consumers pay quarterly. We have the city divided into three districts and our meter readers read one district each month and that district is billed for payment the first of the following month. Ten days are allowed for payment in order to secure a 10 per cent discount on the amount of the bill. The next month the second district is read and the third month the third district. This brings us a collection period each month and distributes the billing uniformly throughout the year. We find it very satisfactory. This permits the use of the same meter readers all the time and provides work enough to keep them busy since they also distribute the bills to the consumers.—W. R. Gelston, Superintendent Water Works Commission, Quincy, Ill.

Boston, Mass.

Water meters in Boston are read, with a few exceptions, once in three months and bills are rendered quarterly. It was our custom before Boston was 100 per cent metered to read them once a month, but with almost 100,000 meters in service, this practice was changed to one in three months. It is, of course, an advantage to both consumer, and city to have a monthly reading, but a much larger force of meter readers would be required, and it is a question as to whether the additional expense would be warranted by the results attained. Many consumers read their meters and are thereby informed as to the consumption and any variation from normal in same. This is especially the case with large consumers. The meter bills give the readings and dates thereof, and thus enable the consumers to check same if they so wish. Furthermore, if there is any unusual increase, the meter reader notifies the premises, or in the event of a decrease, the department is notified.—George H. Finneran, Superintendent, Water Service, Water Division, Public Works Department, Boston, Mass.

Wauwatosa, Wis.

We read water meters every month but bill the consumer every three months. The reason for reading the meters every month is to check leaks in the plumbing that the consumer is unaware of until the meter reader reports same. He also discovers meters that are out of order so that they can be repaired at once. We find that this has worked out very satisfactorily and has in some cases benefited the consumer by finding the leaks in the plumbing.—A. W. Hebbring, Superintendent of Water Works, Wauwatosa, Wis.

Binghamton, N. Y.

For one and two family houses meters are read four times a year and are billed but once a year. Apartment houses of three families and over are read four times a year and billed twice a year. All business places, including hotels, railroads, etc., are read and billed every two months.—H. M. Gitchell, Superintendent, Bureau of Water, Binghamton, N. Y.

Davenport, Iowa.

It is our practice to read and bill all industrial, commercial and municipal meters monthly. Domestic meters are read and billed once in each three months. One-third of the domestic meters are read each month and the territory is divided into three districts for this purpose. This plan is satisfactory.—Charles R. Henderson, Manager, Davenport Water Co., Davenport, Ia.

Holyoke, Mass.

For all users of large amount of water, such as mills, the meters are read and bills rendered monthly. For apartment blocks meters are read monthly and bills rendered quarterly. Residences are not metered.—Patrick Gear, Superintendent of Water Works, Holyoke, Mass.

Worcester, Mass.

Meters are read in Worcester each month. Bills are rendered every six months.—Leon A. Goodale, Commissioner and Registrar, Water Department, Worcester, Mass.

SOME IMPORTANT PHASES OF SEWAGE CHLORINATION

By HARRY E. JOHNSON
Chemist in Charge, Sewage Works, Flint, Mich.

Harry E. Johnson, Superintendent Sewage Disposal Works, Flint, Mich.

THE field of sewage chlorination has brought forward a number of problems that were never encountered in the chlorination of potable waters. In many instances it is highly important to decide on the most economical method of application of chlorine to a given sewage for a desired result. This is particularly true where the chlorine is to be applied to sewages for the purpose of oxygen demand reduction or odor control.

Chlorine efficiency is dependent upon a number of variable factors, most important of which are:

1. Point of application
2. Method of application
3. pH of sewage
4. Presence of industrial wastes.

The wide variation in the sewage composition of various cities makes it difficult to compare results obtained at one sewage treatment plant with those of another, and in many instances a thorough study of the reaction characteristics of the sewage to be treated will result in a considerable saving in the cost of chlorinating equipment and chlorine.

Point of Application.—This subject has been discussed so often that it is barely necessary to repeat that the greatest economy can most often be obtained by treating the sewage as far ahead of the treatment plant as is practicable. The point of application, however, should be such that no marked reseeding of the chlorinated sewage from laterals below the point of application will take place. Where long interceptors connect the main sewerage system to the treatment plant, it may happen that split treatment will prove necessary, due to secondary septization of the sewage in the interceptor. This is particularly true when solids are deposited in the sewer. The advisability of split treatment, however, is somewhat doubtful. Quite often it will be found that moving the point of application nearer to the treatment plant will result in a greater chlorine economy than would be obtained by double chlorination. One, instead of two, chlorinating stations has its advantages also from the standpoint of operation.

Methods of Application.—This is an important point to consider, and one that has only recently come to the front. The correct method of application depends upon a number of variables, chief of which are the affinity of the sewage for chlorine (which depends upon the concentration, freshness, average temperature, and presence of industrial wastes), and the availability of an ample water supply to operate the chlorinators.

Since the consumption of chlorine added to sewage follows the law of mass action, it is advisable to keep the chlorine concentration at a minimum at any point in the sewage flow being treated. Gaseous chlorine or chlorine water solution in high concentrations tend to react with the organic matter in sewage at an amazing rate, and to a degree far in excess of the apparent chlorine demand when determined by rapidly mixing sewage with chlorine. This excess chlorine reacts chemically with the humus matter in the sewage forming permanent chlorine, and, perhaps, separable chlorine compounds which have slight if any disinfectant action. The tendency toward super reaction is greatest with sewages having a high chlorine demand, particularly if the sewage is warm. It occurs almost as readily with chlorine solutions as with gaseous chlorine if the distribution of either is inefficient or slow.

The ideal method of applying chlorine solutions would be in very dilute solutions, slowly and with constant agitation such as is possible when titrating the chlorine demand in the laboratory. Since this is obviously impossible, the same results (practically) can be obtained by proper distribution of the chlorine in the whole of the sewage flow. With solution feed equip-

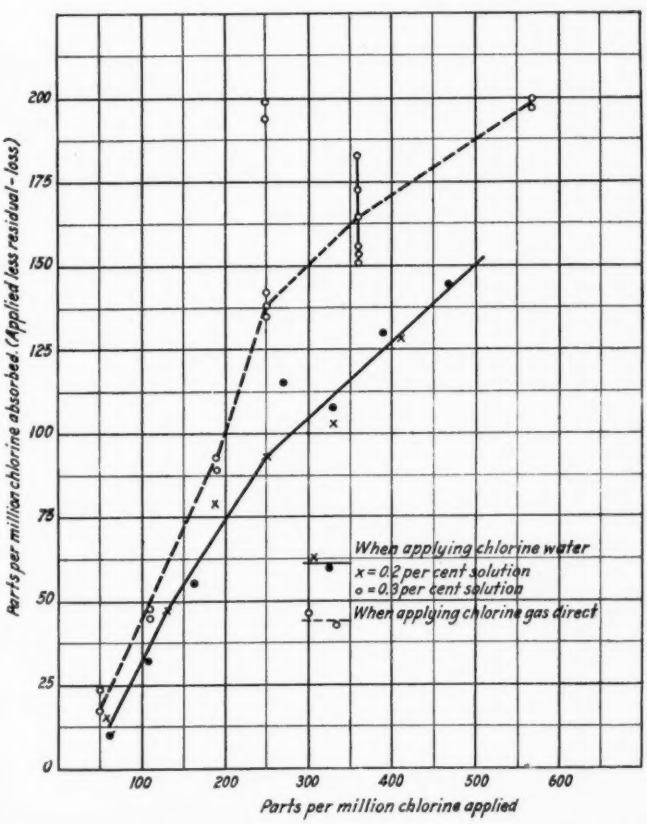


Fig. 1—Comparison of Chlorine Losses by Absorption Which Results from Superchlorination Caused by Poor Chlorine Distribution

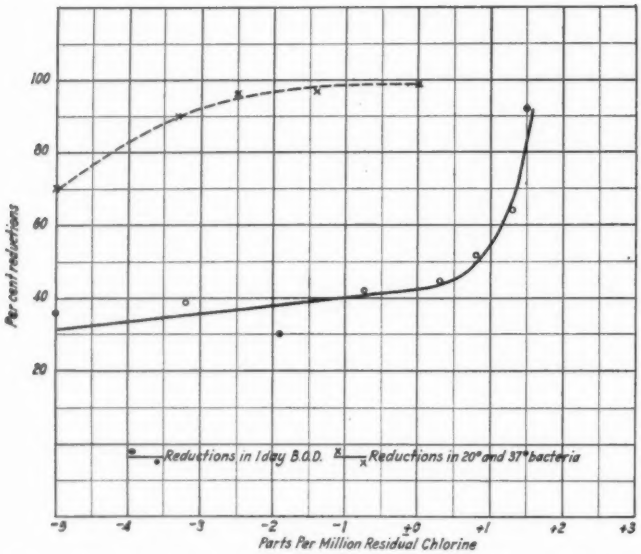


Fig. 2—Curves Showing Effects Secured from Chlorine Applications Approaching and Equalling That Required to Satisfy the Chlorine Demand

ment it is necessary to feed the chlorine solution through an efficient distributor placed in such a position that the chlorine solution is instantaneously applied to all parts of the sewage flow. It is also important that no back eddies occur that would allow the sewage to come in contact with chlorine more than once. Difficulties with such distributors are often encountered because of rags and other debris in unscreened sewage.

A new method of direct application has recently been perfected by chlorinator manufacturers in which an "Impulse" or "Impact" diffusor is used. This diffusor operates with a very low water consumption on the principle of an atomizer, and gives remarkable results when properly installed. Where a clean water supply is limited this type of equipment offers a considerable saving on water as well as in initial cost and gives a high efficiency of application of chlorine.

Recent studies by Enslow* and others have shown that application of lime-chlorine mixture (hypochlorite) permits an even greater economy in chlorine and the equipment costs in this case are also low. The method consists of making a milk of lime solution, preferably by use of a dry lime feed machine, and adding chlorine to the milk of lime in such proportion that a slight excess of lime is still present and applying the hypochlorite solution to the sewage to be treated. It is claimed that the distribution of the hypochlorite solution has little bearing on the efficiency of application and that the saving on chlorine more than pays for the cost of the lime, but this again depends upon the peculiar characteristics of the sewage being treated. All things being equal, good distribution is a desideratum.

pH of Sewage.—In this connection, a series of studies were make at the Flint, Mich., sewage treatment works to study the reactions of lime-chlorine mixture, hypochlorous acid, and chlorine water on sewage in which the pH had been previously adjusted over a range of pH 5.0 to 9.0. The main points of study were chlorine economy, effectiveness of sterilization and persistency of the chlorination effects. The sewage samples were treated with each chlorine carrier to obtain a residual of 1.0 p.p.m. and the persistence of residual was noted. After the disappearance of residual a portion of the sample was adjusted to pH 7 and both portions were seeded with septic sludge liquor from digestion tanks. Bacterial development was noted in the seeded samples.

From these experiments it was noted that chlorine consumption was lowest at pH 7.0 with all three carriers. Below pH 7.0, lime-chlorine mixtures were the most economical, with hypochlorous acid† next and chlorine water least. Above pH 7.0 the hypochlorous acid and chlorine water proved somewhat more economical. No great difference was noted in the persistence of residual in strong settled sewage from the Flint Imhoff tanks at any pH with any of the three reagents.

The effectiveness of sterilization was greatest at pH 7.0 with all three reagents although the order of economy per unit of chlorine was (1) hypochlorous acid, (2) chlorine water, (3) calcium hypochlorite. In acid sewages, no doubt, the lime-chlorine mixture would afford the most effective and economical treatment, while with neutral or alkaline sewages hypochlorous acid comes first, with chlorine direct or in solution a close second. Thus it can be seen that the average pH of the sewage to be treated has an important bearing on the type of treatment to be used.

Presence of Industrial Wastes.—The last mentioned problem in connection with sewage chlorination is the reduction of the chlorine demand of the sewage. This problem deserves considerable study if the cost of treatment is to be kept at a minimum. In a large number of instances, high chlorine demands in sewage are caused by the discharge of industrial wastes to the

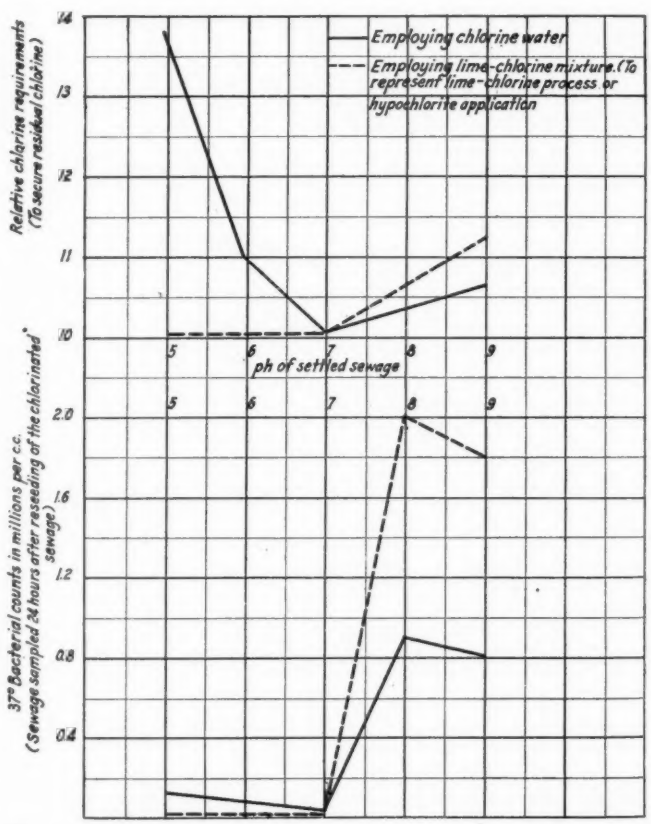

Relative chlorine requirements (To secure residual chlorine)
Employing chlorine water
Employing lime-chlorine mixture. (To represent lime-chlorine process or hypochlorite application
ph of settled sewage
37° Bacterial counts in millions per c.c. (Sewage sampled 24 hours after reseeding of the chlorinated sewage)

Fig. 3—Comparison of Chlorine Absorption and Bacterial Aftergrowth in Chlorinated Sewage 24 Hours After Inoculation with Digestion Tank Liquor

*Ammonia-Chlorine Reactions and Lime-Chlorine Process. L. H. Enslow. Water Works and Sewerage, Mar., 1931, vol. 78, no. 3, pp. 55-59.

†Prepared from chlorine water to which marble dust or pulverized limestone is added.

sewers. These wastes may be divided into three classes:

1. Those that have a high chlorine demand in themselves and that produce still greater chlorine demand when discharged into sanitary sewers, due to the decomposition of sulphur compounds in the waste or sewage.
2. Those that have a high chlorine consuming capacity but do not decompose, or cause decomposition in the sewers.
3. Those that have no chlorine demand in themselves but contain sulphur compounds which break down in the sewers forming hydrogen sulphide, thereby increasing the chlorine demand of the sewage.

The first class of wastes causes the most serious trouble where the sewage is to be chlorinated. The ammonia still residues from coke by-product plants constitute wastes of this class and are common offenders. These wastes have an enormous chlorine consuming capacity and, furthermore, are loaded with thiosulphates and other sulphur compounds which are very unstable when mixed with sanitary sewage. The primary effect of such wastes is to immediately increase the chlorine demand by their mere presence in the sewage. Due to the reducing power of the wastes and the quantities of sulphur compounds present, the free oxygen in the sewage is rapidly used up and anaerobic decomposition quickly sets in. The secondary effect is a rapid increase in odors accompanied by a proportionate increase in the chlorine demand of the sewage. Every effort should be made to eliminate the objectionable qualities of wastes of this nature at their source or compel the industry to stand its prorated share of the treatment cost. Wastes from meat packing establishments fall in this class and are common.

The second class of wastes causes only one effect in sewage and that is an immediate increase in the chlorine demand. Any strong reducing agent will fall in this class and if the sewage is low in sulphur compounds no further increase will take place. Waste of this nature may be treated either at the source or at a later time with little effect on the economy of treatment.

The third class of wastes certainly requires treatment at their source if the cost of treatment is to be kept at a minimum. Each case requires individual study and the effect of wastes or the elimination of them from the sewers should be taken into consideration when estimates for equipment are being made. Often a considerable saving in equipment and treatment costs will follow a systematic study of the wastes present in a given sewage.

As a final study in chlorine demand reduction it is advisable to search the entire sewer system for points of stagnation and for deposits of sewage solids which infect the entire sewage flow. Correction of such conditions will often result in a fresher sewage at the treatment plant and a material reduction in chlorine requirement.

It is generally not understood that chlorination costs can be reduced materially if some study is given the existing situation and corrective measures, many of which are reasonably simple, are adopted.

Acknowledgement.—The writer wishes to acknowledge the loan of equipment by the Wallace & Tiernan Co. and the Paradon Mfg. Co., and also wishes to thank L. H. Enslow of The Chlorine Institute who has followed this work from start to finish.

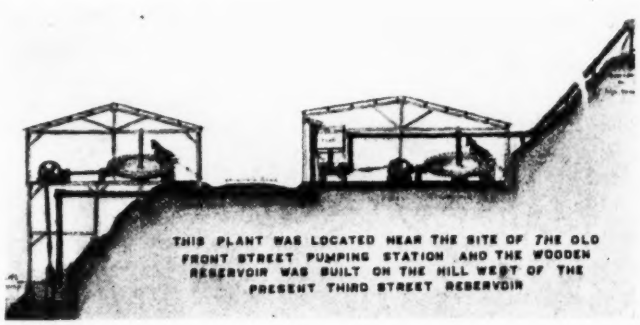
Cost of Filtering Water of Cincinnati, Ohio

The following table from the report of Clarence Bahlman, Water Purification Supervisor, in the last annual report of the water works department of Cincinnati, O., shows the cost of filtered water per 1,000,000 gal. delivered into service for the period 1908-1929.

Year	Operation: Chemicals	Operation: All Other Operating Costs	Maintenance	Total
1908	$1.72	$2.47	$0.05	$4.24
1909	1.89	2.28	0.09	4.26
1910	1.93	1.98	0.28	4.19
1911	1.85	1.91	0.35	4.11
1912	1.78	1.68	0.38	3.84
1913	1.67	1.77	0.48	3.92
1914	1.21	1.78	0.39	3.38
1915	1.43	1.86	0.76	4.05
1916	1.27	1.80	0.38	3.45
1917	1.86	1.85	0.40	4.11
1918	2.27	2.22	0.67	5.16
1919	2.45	2.44	0.99	5.88
1920	2.26	2.62	1.04	5.92
1921	2.55	2.30	2.16	7.01
1922	2.64	2.76	1.19	6.59
1923	2.53	2.85	1.38	6.76
1924	2.68	2.71	1.96	7.35
1925	2.10	2.86	1.69	6.65
1926	2.50	2.89	1.68	7.07
1927	2.32	2.85	2.27	7.44
1928	2.18	2.40	2.22	6.80
1929	2.29	2.37	3.42	8.08

Governmental-Cost Payments

The Bureau of the Census, U. S. Department of Commerce has issued recently a bulletin containing the financial statistics for 1929 of cities having a population of over 30,000. The total cost of government in 1929 of the 250 cities in this class amounted to $3,435,289,927. An analysis of this total shows that the costs for the operation and maintenance of the general departments were $1,935,876,752, a per capita of $43.68, and representing 56.4 per cent of all costs of the 250 cities; operation and maintenance of public service enterprises, such as waterworks, light plants, public markets, and similar enterprises, $166,657,371, a per capita of $3.76, and 4.9 per cent of the total; interest on debt, $365,690,796, a per capita of $8.25, and 10.6 per cent of the total; and for outlays, or permanent improvements of general departments and public service enterprises, $967,065,008, or 28.2 per cent of the total cost.


THIS PLANT WAS LOCATED NEAR THE SITE OF THE OLD FRONT STREET PUMPING STATION AND THE WOODEN RESERVOIR WAS BUILT ON THE HILL WEST OF THE PRESENT THIRD STREET RESERVOIR

Pumping Plant of Cincinnati, O.

The above is an illustration of the pumping power for the water works of Cincinnati installed in 1821. It will be noted that this is a two horse power plant.

THE WATER WORKS MAN AND THE PUBLIC

By H. B. RICHARDS

Superintendent, New Castle Water Co., New Castle, Pa.

SO far as the water works business is concerned, the interest of Mr. John Doe is limited to the bill you render him every quarter. He usually mails you a check, and by reason of the lack of personal contact, year after year, the water company becomes to him a machine in which no human element is present. He gives no thought to your problems of operation. He is not interested in your problems of finance, because for him they do not exist. He draws water from the tap when he wants it, and as much as he wants, safe and pure, and it does not occur to him that the cost of the service you render is constant research by trained minds, and the loyalty and eternal vigilance of a faithful crew on duty from dawn to dawn. The romance of water has not touched his soul, and that it has not, is out fault, not his.

Why People Disagree.—The principal reason that people disagree with each other, is because each approaches a controversy from his own side of the fence. He is so dead set on his own rights, that he does not think he has any interest in the other fellow's viewpoint. If water works' employees, as a class, were trained to step into the other fellow's shoes, and approach the customer's problems from the customer's side of the fence, it is likely that a large part of the question of good public relations would be speedily solved.

Of course it is a fine thing to make speeches to the various civic organizations, for that brings your story to a large number at one time, but to be permanently worth-while, these must be followed up with, and preceded by, individual, personal contacts with Mrs. Jones, and Mrs. Brown and Mr. Smith.

The Value of Personal Contacts.—Mrs. Jones does not care very much whether you have to sit up nights nursing trouble at the filter plant, or not, but she is intensely interested in getting a sufficient supply of water through the hose to water her garden; and Mr. Smith may not bother much over the fact that you have to lay a main which will not pay dividends, but he is apt to be hopping mad if somebody draws water down stairs while he is shaving.

These good people are just average people, which make up the mass of our consumers, and they are moved by the same traits of human nature, and form the same prejudices that other normal people form. They don't expect any relief, because in their minds public utilities are popularly presumed to be above paying much attention to the petty griefs of their consumers, only with the average consumer, his grief is never a petty one—his trouble is a source of constant aggravation, and looms large on his horizon.

And so when the superintendent of the water company, or some one else in authority, drops around and shows Mrs. Jones that her trouble is caused by using an old ½-in. hose, which is all kinked up and has the lining broken and wrinkled, and completes the demonstration by dragging a new ¾-in. company hose out of his car and throwing water all over her lawn, he is apt to change Mrs. Jones from a carping critic to an ardent partisan.

The Case of Mr. Smith.—And if he calls on Mr. Smith and explains the difference between pressure and volume and shows him that his house lines are all too small and badly corroded, and agree that if Mr. Smith will renew his pipe lines as suggested, the water company will renew the street service line, and after this is all done if Mr. Smith is not satisfied with the service he gets, the water company will foot the plumber's bill, he is apt to think that it is a fairly decent water company after all. And when all the changes have been made, and he finds that the service is even better than the superintendent had led him to believe, it would be a foolish man who would stand up in any crowd where Mr. Smith was present, and declaim that the water company mains were too small for the service that it was supposed to render.

The Problem of the Higher Bill.—There are few people who can think of more than one thing at a time, and that is especially true, when they are mad. It is therefore plain that when a customer comes to the window with blood in his eye, and a bill for $4.87, when it normally runs $2.50, the only thing he thinks about or wants to talk about is a reduction of that bill. You are not going to get anywhere trying to argue him out of his position, because he knows in advance that you are bent on hooking him, and he won't even work up a healthy interest in your arguments.

So when the girl at the window has gone as far as she can without any result, and you are called to settle the matter, knowing something of human nature, your first move is to get his mind off his particular grief in a diplomatic sort of way. You grin and say "good morning," and politely reach out and take the water bill from his hand and turning it over say "How long have you lived at this property?" He is somewhat disarmed for the moment; he has lost control of the bill, and that bill in his hand was a big stick in what he thought was a fight. And then your asking him how long he has lived at his home—he was not expecting that kind of resistance, and in trying to get himself oriented, surprising as it may seem, he has lost a good deal of his desire to fight.

You invite him in, and together you look over his ledger record, and discuss what his consumption has been in the past. You take occasion to point out to him how the record is kept, and what the various postings on the sheet represent, meanwhile analyzing in your mind what the answer to his problem might be. Quite likely your customer begins to feel that instead of staging a fight, he is really having a visit with you, especially when you look at your watch, and suggest that you have a few minutes to spare, and would like to drive up with him and look his premises over, implying perhaps the possibility that the meter reader may have made a mistake. At his home you show him that the meter has been read correctly, and checking over the plumbing, find for him where the washer in the toilet valve has worn, so that there is a constant leak through the overflow pipe. He hates to pay the bill, of course, but he is satisfied that your company

is square with the world, and that is the kind of public relations you want.

The Superintendent Builds Good Will.—It is one thing to send out a subordinate to investigate a complaint. It is quite another matter, for the superintendent to call in person, and sit on the kitchen table chinning with the housewife for half an hour or so, perhaps over inconsequential things having no relation to the matter in hand. It takes time of course, to compliment the lady of the house about the flowers in the back yard, or to chuck the baby under the chin, and listen to a recital of its accomplishments, but that builds good will that money cannot buy, and paves the way for lasting business friendships.

When the Lady of the House Gets Mad.—Some time since, the phone rang, and when the girl lifted the receiver, you could hear the lady at the other end of the line all over the office. She said "Let me talk to the superintendent, and don't you dare give me anybody else."

The call was switched to my desk, and when I said "Good morning" she said "Don't you good morning me—you have ruined $200 worth of my clothes and you come right up here and pay me for them; and don't you send any boy up here to tell me my hot water boiler is dirty; my husband told me it wouldn't do any good to complain—nothing would be done; but I'm telling you something is going to be done, right now."

You can believe me or not, but that woman was mad. During my long and virtuous career, I have smiled, and taken a good many tongue lashings, deserved and otherwise, but never have I been swamped with the eloquent flow of words that poured from that lady's lips. After what seemed an interminable time, managing to get a word in edgewise, I said, "Won't you please listen to me for a minute?" She flared back "I don't want to listen to you at all—you are going to do the listening."

What are you going to do with a thing like that? An impossible situation.

Reason might dictate that the thing to do would be to drop it and forget about it on the theory that any attempt at explanation would only add fuel to the flames. But the fact is that when you are hopelessly and absolutely lost, you can't get any more lost by going a little further; and you may find a way out.

Well in about three hours I called on the lady. Evidently she was not expecting me. When she answered the bell I said "I would like to meet the lady who scolded me so severely this morning." In spite of herself she had to grin, and when I added "If I had known you were a red headed girl, I would have waited a couple of hours more," she said, "Well, I was pretty mad this morning, anyway." "Madam," I said, "I'll tell the world you were mad."

Anyway we went to the kitchen, and looked at the spots on the clothes she was ironing, discussed causes and effects, and showed her a way to get rid of the spots.

A neighbor came in and joined the party. There was a bare spot on the wire of the electric iron. We hunted up a screw driver and moved up the plug on that. The neighbor said there was something the matter with her electric refrigerator—every time the current went on, the lights around the house dimmed down; maybe the current was weak.

"Well," I said, "the thing to do, is to get the electric light people down here and take the hides off them," so I called the manager of the light company, and asked him to hop into his machine, and meet me there. In ten minutes he had arrived, and told her what to do.

My red headed friend cut up a custard pie before we left. I do not care for custard pie, but if eating custard pie will improve public relations, the thing to do is to eat custard pie.

Incidentally, the main text of this paper was read at the convention of the Penna. Water Works Association last fall, and following the usual custom, it was published as a special pamphlet for general distribution, and I mailed a copy to my red headed sweetheart.

The next day she called me up again, and said that I had a lot of nerve to publish that story about her, and the only reason that she had for forgiving me, was that her name had not been mentioned. Just the same, she was tickled pink at getting into print, because she showed the article to all her friends. This one little incident has done us a world of good, because quite a few people who otherwise did not know us, have come to understand that the water company is a human institution, run by human beings.

The Window Contacts.—But is not all feasible for the executive to meet in person, all of his customers. Most of the contacts are through the girl at the window, the meter readers, the off-and-on man and the repair gang. The reaction of the public toward your company is very largely the reflection of the way they are met by your employees.

If the girl at the window, day in and day out, can meet all the customers with a smile, bless her soul, you have a jewel.

If the girl at the telephone has a soothing voice, in which no note of irritation ever sounds, you are apt to have a good many people think well of your company.

If the meter reader is courteous, your patrons will likely have a pleasant word for him and for you, because they measure your firm by the people who represent you.

And if the foreman is scrupulous about notifying all the people in the block, before shutting down a line for repairs, and refrains from blocking up the driveways, and otherwise discommoding innocent citizens, and leaves a neat decent job behind him, the chances are that a good many people will think that he represents a pretty decent company.

One of the things most destructive of good public relations, is the matter of shutting off for non-payment, especially where the man of the family is out of work. In our town, in common with the rest of the country, there has been an unusual amount of unemployment during the past half year, and when people absolutely can not pay, we have been letting a good many of them work out the bill in the labor gang. Our practice is, to let the man work about two days longer than is required to work out his bill, so that after he pays us we send him away with at least $8.00 in cash in his pocket. We try to arrange our work so as to have places where we can use this kind of help, usually in the pipe line gang, and the good will, and favorable advertisement built up by this plan, is almost beyond belief.

Another kink which has been found of value is to make a practice, as far as consistent, of employing extra help on large pipe line jobs from the immediate vicinity in which the line is being laid. This has the effect of making the people of the neighborhood feel somehow, that they are a part of the water company, and have a definite interest in its welfare.

Of course all this makes a good deal of confusion for the office force, and for the paymaster, but the

thing you want to get over, not only to the general public, but also to your own organization, is that the water company belongs about as much to the public as it does to the stockholders, because in the last analysis, a public utility is, by its very nature, a business held in trust, and operated for the benefit of the public.

No water works operator has done a real job with the talents placed in his keeping, unless a portion, at least, of the public he serves, has acquired the habit of sticking its thumbs in the arm holes of its vest and speaking of the water company as "Our Water Company."

Acknowledgment.—The foregoing is an abstract of a paper presented June 26 before the meeting of the Pennsylvania Water Works Operators' Association.

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Furnishing Water to Out-of-Town Consumers

By ALBERT HEARD

Superintendent and Secretary, Board of Water Commissioners, Hagerstown, Md.

The City of Hagerstown, Md., is probably in a different position regarding furnishing water to out-of-town consumers than most communities, owing to the fact that our water mains leading to the city distribution system from both sources of supply, the mountain reservoir on the east and the Potomac River pumping plant on the south, run along state highways, thereby making no expense to the city for connections for consumers. They pay for service pipes. We also have a water supply greater than the demands for a city three times as large as our present one.

Rates for Out-of-Town Consumers.—We now have a capacity from the two sources of supply of 13 m.g.d., while our entire consumption, including outside consumers, is a little less than 4.5 m.g.d. Our rates to all out-of-town consumers are 20 per cent higher than city rates, and on all pipe lines on streets requiring pipe extensions, a signed agreement is required from all property owners guaranteeing a return of 10 per cent on the investment for pipe lines installed.

The method used by the private company before city ownership was to me a more satisfactory arrangement than the present one, as under private ownership the property owners requesting water service were required to pay in cash the entire cost of extensions immediately upon completion of work. The money so paid was refunded only after the revenues from the sale of water through these extensions equalled 10 per cent per year on the entire cost for three consecutive years.

This method was a better investment for the company, as it created an incentive to hurry the building of houses to insure the return of the money advanced and the company was not compelled to lose the interest on this money for at least three years. However, we now solicit consumers outside the city in order to increase our consumption, which not only increases our revenue, but cuts the cost of pumping per million gallons, since by running pumps to capacity the cost is materially reduced. Our pumping units are of 5,000,000 gal. capacity each and by pumping this amount daily the cost is reduced at least $10 per 1,000,000 gal. At present, when using part mountain water, we furnish only about 2,500,000 gal. through pumping. The balance is from our mountain supply, and for this reason we hope, through out-of-town consumers, with this slight increase in rates, to accomplish good results.

Supplies to Neighboring Towns.—This city is supplying two small towns, Williamsport and Funkstown, Md., with a combined population of approximately 1600. These towns are furnished water through a master meter at a fixed rate per 1000 gal. and a minimum yearly rate to take care of fire protection, until consumption equals this minimum rate. Then a new contract is to be made, extending over a period of five years. During the past year, when a great many water companies were curtailing their consumption owing to dry conditions, this city was soliciting more consumers in order to get the revenues and reduce pumping expenses.

Acknowledgment.—The above is a paper presented April 1 before the Four States Section of the American Water Works Association.

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COMING CONVENTIONS

Several important conventions of interest to water works superintendents and other municipal officials will be held next month. The New England Water Works Association will hold its 51st annual convention at Boston, Mass. The American Public Health Association, which has several sections for sanitary engineers, meets at Montreal, Que. The International Association of Public Works Officials will hold its annual convention in New York City. This association was formerly known as the International Association of Street Sanitation Officials. Its scope has been broadened as is indicated by its new name. The following is a list of some of the conventions that will be held in the near future:

AMERICAN PUBLIC HEALTH ASSOCIATION.—Annual convention, Sept. 14-17, Montreal, Canada.

INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS.—The annual conference of this association will be held Sept. 24, 25 and 26, at the Pennsylvania Hotel, New York, N. Y.

AMERICAN ASSOCIATION OF ENGINEERS.—The 1931 convention will be held Sept. 28, 29 and 30, at Huntington, W. Va. M. E. McIver, secretary, 8 South Michigan Ave., Chicago, Ill.

NEW ENGLAND WATER WORKS ASSOCIATION.—Annual convention, Sept. 29-Oct. 2, Hotel Statler, Boston, Mass.

INTERNATIONAL CITY MANAGERS ASSOCIATION.—Annual meeting, Oct. 7-10, at Louisville, Ky.

CENTRAL STATES SECTION, A. W. W. A.—Annual convention, Starrett's Netherland-Plaza Hotel, Cincinnati, O., Oct. 8-9. B. J. Lechner, secretary-treasurer, Commissioners of Water Works, Erie, Pa., is secretary-treasurer of the section.

SOUTHWEST WATER WORKS ASSOCIATION.—Annual convention, Jung Hotel, New Orleans, La., Oct. 19-22. Lewis A. Quigley, superintendent, water works, Fort Worth, Tex., is secretary-treasurer.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Annual meeting, Oct. 19-26, at Pittsburgh, Pa.

ROCKY MOUNTAIN SECTION, A. W. W. A.—Fifth annual convention, Oct. 21-23, Denver, Colo. Dana E. Kepner, 226 Continental Oil Bldg., Denver, Colo., is secretary-treasurer.

MISSOURI VALLEY SECTION, A. W. W. A.—Annual convention at Eldridge Hotel, Lawrence, Kan., October 29-31. Earl L. Waterman, professor of sanitary engineering, University of Iowa, Iowa City, Ia., is secretary-treasurer.

NATIONAL MUNICIPAL LEAGUE.—Annual meeting, Nov. 9-11, at Buffalo, N. Y.

HOW PIPE SEWERS ARE MAINTAINED AT TRENTON, NEW JERSEY

By A. C. GREGORY

Engineer of Sewer Lines, Trenton, N. J.

THE sewer system of Trenton consists approximately of the following: 121 miles of sanitary sewers, 15.4 miles of combined system sewers, 33 miles of storm sewers, 3,038 manholes, 637 flush-basins, including both automatic and hand flushers, and 1,600 inlets. The mileage of sewers, above stated, refers to main sewers and not house connections.

Our sewer maintenance force has grown from six men in 1900 to 21 men and a superintendent. The men are on steady time and normally work 8 hours per day. As a result, we are able to get the pick of the sewer laborers of the city. Many of them are men who acted as contractor's foremen before coming with us. A Federal truck is used for transporting men, tools and equipment, and there is also employed a 1-horse cart and two Elgin Educators.

The work covered consists in cleaning, repairing, rebuilding inlets, sewers, manholes and flush-basins. Each year a considerable amount of entirely new construction takes place.

The following is a list of some of the routine work done during the year 1930:

Inlets cleaned	7,527
Inlets repaired	25
Inlets built	55
Inlet pipe cleaned	110 ft.
Inlet pipe repaired	34 ft.
Inlet pipe new	548 ft.
Rebuilding of storm sewers	663 ft.
Storm sewers cleaned	4,400 ft.
Main sewer cleaned	36,800 ft.
Manhole buckets emptied	1,114
Manholes repaired	15
Manholes built	32
Manholes raised or lowered	42
Sewer connections cleaned	224 ft.
Sewer connections repaired	1,024 ft.
New sewer connections built	2,150 ft.

Sewer building in Trenton got under way in 1890. Many of the main trunk sewers were built during the next ten years. The building of secondary trunks, laterals and storm sewers has been largely effected since 1900.

Automatic flush-basins were installed on nearly all lateral sewers. Soon after the advent of Commission Government in Trenton a check-up was made on the amount of water used or wasted and the flushers of the sewer system were placed under scrutiny. The water passing through the flushing basins was found to average 3,266,000 gal. per day, a rather amazing figure, and one which justified experiment with a view to finding what would happen should the water supply of the automatic flushers be shut off or used occasionally. Accordingly, the water supply was shut off on all flush-basins at the heads of sewers with grades of 0.5 per cent or greater.

In the experience which followed, it was found, generally, that very little flushing was necessary, particularly in sewers with grade above 0.6 per cent. It seems evident that in a fairly well built up street, the water flushed from the sewer connections of say two dozen houses is usually sufficient to move the sewage solids to the intercepting trunk where there is a greater depth of flow. This does not mean we are not heartily in favor of flush-basins. They are a factor of safety, allow the control of danger spots and with occasional use when they are needed are decidedly an essential part of the sewer system.

At the present time, we estimate that under 300,000 gal. of water per day is used for this purpose.

Stoppages.—We have the usual main sewer stoppages resulting from the introduction of sand, sticks, rags, roots, etc., into the sewer.

As has been stated, we do not make periodic inspections of main sewers. Most of the stoppages encountered are in house connections, and there presence is unknown until complaint is made by the house holder. The city is responsible for house connections stopped up between the main sewer and curb. The relieving of a house connection stoppage is usually a matter of digging up the connection, relieving and repairing it and replacing the back-fill and pavement. The latter item, since the advent of expensively paved streets, has become a factor of expense, and during 1930 amounted to $1,820.

Apart from what we may call routine stoppages, as those due to causes already mentioned, we have had the following experience. The trunk sewers built up to 1903 were of brick. Each was provided with vitrified slants for house connections. Where such sewers were of considerable depth, 6-in. vitrified standpipes were built vertically up from bends joining the slants to a plane perhaps 10 ft. below the surface of the street. With sewers 15 ft. deep or more there has been a decided tendency for the standpipe connection to shear off at the slant. This is evidently due to the gradual settlement of earth in the trench, carrying with it the standpipe and has occurred frequently, and to the extent of ruining almost all the sewer connections in certain blocks. When a condition like this takes place, we have in a number of streets found it economical to build a paralleling sewer, usually an 8-in. pipe above the old trunk. This is vented into the nearest manhole on the old sewer, and the old connections are joined to the new sewer. Usually the trunk sewers concerned were sufficiently large to allow a man to go inside and stop up the old slants so as to prevent the entrance of earth. The shearing off of slants in that part of the city south of the Assunpink has on several occasions narrowly escaped being a disaster. The soil of this region is sand, and due to the sand being carried into the sewer slant as a result of the stream of sewage from the house connection or to a broken water service pipe, a veritable cave has been formed under the asphalt pavement, followed by the collapse of the latter. In cases where only one or two standpipes have gone down, we have found that with a well-rammed bearing of concrete under the slant and with a standpipe carried up with a bearing against the earth of at least 15 deg. with the vertical, no after trouble need be expected.

Another stoppage peculiar to this city has been the clogging of the sewer by pottery-slip. This is a very finely divided clay entering the sewer with sufficient water to cause it to flow. When sedimented in the sewer, it forms a sticky and obstinate mass, and cannot be flushed out. The trouble is rapidly being eliminated by the co-operation of the potteries who pass the slip through sedimentation basins where it undergoes sedimentation for from 15 to 20 hours, giving an effluent which causes no trouble whatever.

Trade waste from some of the rubber mills, up to a few years ago, also caused stoppages in main sewers. The hot rubber waste flowed into the sewers and formed a sponge-like mass completely filling the bore of the sewer and exceedingly difficult to dislodge. Manholes 250 ft. apart gave no control of the sewer, and it had to be dug up at intervals of 125 ft. or less. This trouble too has been eliminated through the co-operation of the rubber mills.

Grease from the kitchens of some of the state institutions have filled adjacent sewers on several occasions. Our experience is that, the beginning of such a stoppage is due to an accumulation of grease around a projection of cement mortar above the sewer invert at a joint. As soon as this begins to build up, the accumulation of grease and solids rapidly takes place back of the joint affected. It is evident that carelessly jointed sewers are not suited to carry away grease laden sewage. Grease traps help, but it is difficult to get them anywhere nearly big enough.

Methods of Cleaning Sewers.—Our principal reliance at present is in the use of jointed sewer rods, a chain contrived by our superintendent of sewer maintenance, wooden cylinders studded with nails and a fire hose stream. Very often a stoppage may be relieved by simply using the rods followed up by a hose stream from the nearest fire plug. When the obstruction is more serious the rods are put through from one manhole to the next and they are generally 250 ft. apart, and the chain is put into use.

The chain is 40 ft. long and is made up of circular links of ½-in. steel. Each link is 3¼ in. in outside diameter and consists of a double spiral with the ends of the bar composing the link not joined but sheared off diagonally so that they have a tendency to pick up and carry along the solids encountered. The chain weighs 150 lb. and is pulled through the sewer, in the direction of flow, by a windless. Six men usually make up a party on such work.

When the rods have passed through the sewer, the chain follows. It may be operated as one long chain or doubled, or even made to fill the bore of a nordinary 8, 10 or 12-in. pipe. When the bore of the sewer is greater, the simple dragging of the chain over the surface of the solid material inside the sewer followed up by a plug stream, effectively moves material which is caught and gathered at the manhole at which the windlass operates. The result of this operation is that much solid material is pushed ahead of the chain, and the chain itself will be solid with material. It very often appears looking like an enormous cylindrical mass of sludge. We have found this device very effective, and from 300 to 750 ft. or more may be cleaned per day with a gang of six men. The length of sewer covered depends, of course, upon the difficulties encountered. We have found the chain very effective in the removal of roots. When the root itself has been penetrated by the rods, there is no difficulty in breaking off its main stem by use of the chain and carrying the root forward.

In the case of 8, 10 and 12-in. pipes there is often used as a sort of finishing tool, a wooden cylinder studded with roofing nails. An iron bar with a ring at each end pass through the axis of the cylinder. The total diameter from out to out of mail heads is ½ in. less than the bore of the sewer. After this is drawn through as a finishing operation the sewer is generally clean and free of fibrous root strands.

Inlets.—We are gradually eliminating older types of inlets and replacing them by those of more modern design, particularly at curb intersections in the more congested parts of the city. Like many cities, we have various types of inlets which have been placed without the slightest thought as to the work they had to perform. There have been many cases where the inlet capacity is but a fraction of the amount of runoff reaching it during heavy storms. It is an old custom with engineers in arriving at the size of storm sewers to labor diligently to determine the amount of discharge which may be expected to reach a given street intersection. The size of the storm sewer is predicated on this, but no thought is given to the capacity of the inlets which receive the storm discharge and convey it to the sewer. This condition we have had in great plenty, and it is one of the factors which is forcing much replacement of inlets as the city and its streets become more impervious.

Inlet Cleaning.—The city formerly attempted to care for its system of storm inlets by means of the employment of horses and carts with two men on each cart. This was found to be cumbersome, unsanitary, and extremely unsatisfactory as to results. In 1925 and 1927 two Elgin inlet eductors were purchased, and have proven very satisfactory in covering the inlet cleaning work. Each of these will clean from 20 to 30 inlets per day. The variation in number cleaned being due to the distance to the dump where the gathered contents of inlets may be disposed. While inlet cleaning is, at best, rather expensive business, it is a very essential one, for there are few matters in a city which bring about conditions of nasty inconvenience and a consequent storm of complaints, more quickly than flooding caused by stopped up inlets or inlets in a malodorous condition.

Hazards.—During the past year, we have come to the conclusion that a very serious feature of sewer maintenance is the matter of its hazards.

We have on several occasions had men injured through accident. Where abrasions of the skin take place, infection is very apt to occur. The writer within the last month approved a hospital bill of $120 which was a cost due mainly to an abrasion of the skin of a man's hand which was injured by sudden contact with a broken connection pipe.

A matter which has engaged the writer's attention is the relative frequency of illness on the part of the maintenance men. No figures have been kept as to number of men ill, and peculiarities of such illness, but data will be obtained and kept during the present year.

Doctor's bills and hospital bills have been presented and paid by the city because of infection and blood poisoning due to accidents and there has recently been a considerable amount of illness amongst the maintenance men involving intestinal trouble.

We are prepared to watch this sort of thing closely during the present year, and in the time to come hope to have some data as to whether illness is more frequent amongst sewer maintenance men than is to be expected in other lines of outside work. If it be true

that there actually is a greater illness hazard in the work, then the next question is: what are we going to do about it. In the meantime, the men on the work are wearing gloves, and washing their hands more frequently than they ever did in their lives.

Acknowledgment.—The foregoing is a paper presented at the 1931 meeting of the New Jersey Sewage Works Association.

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Annual Meeting of the Pennsylvania Water Works Operator's Association

The registration for the Fourth Annual Conference of the Pennsylvania Water Works Operators' Association totalled 202, a 25 per cent increase over last year's attendance of this fast-growing association. The meetings were held on June 24, 25 and 26, and as usual, at State College, Pennsylvania. Lodging was provided for the members and guests in the new dormitories of the Pennsylvania State College which has sponsored the organization of the association.

One hundred and twenty persons attended a pre-convention session on "Elementary Principles of Water Purification" with Mr. M. E. Flentje of the Supervising Engineers, a subsidiary of the Community Water Service Corporation, in charge. Demonstrations were made of the mixing and coagulation of hard and soft waters, exhibits were shown of typical bacteriological plates, and descriptions of the operations of the various plant units were given. It is probable that this feature of the convention will be followed out in future sessions.

The regular session was opened by an address of welcome by Professor Elton D. Walker, head of the department of civil engineering of the Pennsylvania State College.

In the "Trouble Hour" which followed many kinks in water works operation were discussed. Among other papers was that of F. H. Knuth of Erie, who described an apparatus installed at the municipal works in that city for the preheating of water to prevent the formation of chlorine ice in the manometer tubes of the liquid chlorine machines. H. M. Searfauss of Harrisburg told of the successful elimination of odors in tap water through the use of copper sulphate in the small pre-settling basins at his plant. Application of this chemical also was of material advantage in increasing filter runs.

The feature paper of the session was, probably, that of Roberts Hulbert of Detroit, who demonstrated very clearly the value of sand expansion as the index for the efficient washing of rapid sand filters, and of the influence of temperatures and size and shape of sand grains on the required rates of wash. The title of his paper was "Filter Washing—Theory and Application of the Sand Expansion Index."

J. J. Shank, Director of the Wayne Laboratories of Waynesboro, Pa., specializing in chemical, bacteriological and metallurgical analyses, presented a very unusual and interesting paper on "The Influence of Soils, Rocks, and Minerals Upon the Potability of Water," describing the various chemical changes in water occurring in rock formations before the water finally emerges from the ground heavily contaminated, chemically, by the solution of various chemicals and their combination and interchange under ground. He demonstrated a striking example of the relative solubility of lead in distilled and normal hard waters.

Another unusual paper was presented by H. B. Richards, Superintendent, New Castle Water Co., New Castle, Pa., on "The Water Works Man and the Public," showing how the confidence of the consumers in New Castle had been completely won by fair treatment and proper approach.

A. E. Howe, of the DuPont Ammonia Corporation of Wilmington, Del., read a paper prepared jointly with Dr. J. F. T. Berliner, of the same company, on "Further Developments in the Ammonia Treatment of Water," a live subject, which provoked much discussion during the regular meeting of the convention and during the "Trouble Hour" and at the Round Table Discussion later in the day.

J. T. Campbell of the J. N. Chester Engineers of Pittsburgh, described the West Side Filter Plant at Erie, now under construction, and brought out reasons, based on observations at the existing filters, for the design of rather standard features.

H. E. Moses, Assistant Chief Engineer of the State Department of Health at Harrisburg, presented, with a number of slides, a description of the effect of the 1930-31 drought on the water supplies of Pennsylvania, which should be invaluable to waterworks men when a recurrence of the extreme conditions of the past year again obtain.

F. W. Bouson, Chief Chemist of the South Pittsburgh Water Co., Pittsburgh, Pa., described the operation of the lime soda softening at the filtration plant at South Pittsburgh, where the hardness of the water reaches a maximum of approximately 500 or 600 parts per million.

J. Z. Columbia, Superintendent of Filtration at Langeloth, gave details on successful methods for the purification of water taken from an upland and rather shallow impounding reservoir regularly infested with algae and other similar microscopic organisms.

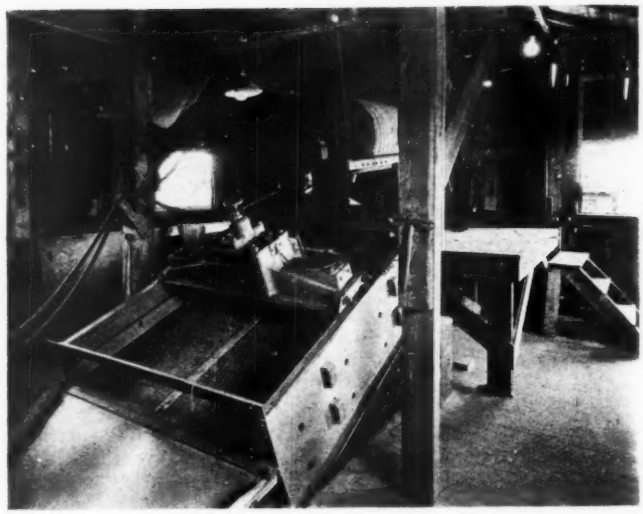
The annual dinner was held in the main dining room of the Nittany Lion, a new hotel located on the college campus. E. C. Trax of McKeesport was toastmaster. In the Round Table Discussion which followed the dinner various authorities were called upon to answer questions submitted on paper by those in attendance at the regular meetings of the association. Mr. Hulbert of Detroit, in answer to a question on actual retention periods of coagulation basins, described how tests were made for determining these periods and how, by proper baffling, the retention period at the large Detroit plant was increased from, roughly, 35 per cent to 70 per cent of the theoretical period of retention.

At the business meeting the secretary was placed on a salaried basis and the following officers were elected for the ensuing year:

President, George R. Taylor.
First Vice-President—E. C. Trax.
Second Vice-President—Martin E. Flentje.
Secretary-Treasurer—I. M. Glace.

The Executive Committee decided to hold next year's meeting at the college, which decision is subject to agreement with the Pennsylvania Sewage Works Association, the annual meeting of which was held just prior to the convention of the Water Works Association, and provided further, that there is no conflict with the annual meeting of the American Water Works Association.

The entire proceedings of the association will be published in the 1931 Journal of the association at an early date.



Interior of Sand Screening House

RESANDING THE FILTERS AT THE WATER PURIFICATION PLANT OF CINCINNATI

AFTER 21 years of operation, the original sand bed in the filters of the water purification plant of Cincinnati, O., had expanded to 42 in. and the fillboard had decreased to an average of but 12 in. During the last few years an ever-increasing loss of sand during the washing process has occurred. In 1907, the sand had an effective size of .34 mm. and the uniformity coefficient was 1.60. In 1929, the sand contained 52 per cent of acid-soluble incrustation; the effective size had increased to .51 mm., and there was practically no variation from this size at any place from the top of the bed down to a point 24 in. beneath the surface. Although there has been no evidence of decreasing filter efficiencies, it was deemed advisable to reconstruct the filters so as to have a greater freeboard. A complete removal of all the old sand seemed unnecessary. The beds were in good condition as regards uniform distribution of wash water and freedom from mud balls and surface cracking. The sand used in reconstructing the filters was prepared from Ohio River sand by dry screening. The methods were developed after about 6 months of preliminary study in the laboratory and in plant filters. How the filters were resanded was described by Clarence Bahlman, Water Purification Supervisor in the recently issued report of the Water Works Department of Cincinnati, O., from which the notes following are taken:

A 30-in. bed of sand, as fine as that placed in the filters in 1907 would give filter runs far too short for present demands, as shown by early plant records, as well as by comparative studies in experimental glass tube filters. Nevertheless the excellent filter efficiencies warranted a trial, in lesser depths, of sand in the neighborhood of .34 mm. effective size.

Filter service of not less than 50 per cent, as long as that being given by the old filters, was fixed as a minimum to be yielded by the new filters. Sand of .33 mm. effective size was produced, and 20 in. of this was placed in Filter No. 13, above 10 in. of the old sand. It was not until after several successive removals of top sand, totalling 5 in., that filter runs of reasonable length were obtained. At such time the effective size at a point 6 in. below the surface was .40 mm.

The same grade of sand was placed in another filter, but only 14 in. were added. Two inches had to be scraped from the top before satisfactory runs were obtained, and the effective size at the 6-in. depth then was .41 mm. It seemed, then, that if 12 in. of new sand was to be placed in the filter, the effective size of such sand, 6 in. from the surface, should be in the neighborhood of .40 mm. The desirability of using a sand somewhat coarser than .33 mm. also was indicated.

Accordingly, a coarser bottom screen was obtained from which was prepared sand averaging .37 mm. effective size and 1.46 uniformity coefficient. Twelve inches of this, over 17 in. of old sand, yielded satisfactory filter service without the necessity of scraping off any sand after refilling the filter.

All but two of the remaining 25 filters, therefore, were reconstructed so as to average, finally, a 12-in. depth of new .37 mm. sand over 16 in. of old sand, and thus to have an average freeboard of 26 in. For observational purposes, only 6 in. of new sand was placed in Filter No. 1, whereas all of the old sand was removed from Filter No. 18 and 30 in. of new sand placed therein.

After the resanding was completed, the average size of the sand in all of the 28 filters, at various depths, was as follows:

Depth	Effective Size	Uniformity Co-efficient
1 in. to 3 in.	.34	1.35
2 in. to 6 in.	.41	1.39
At 6 in.	.42	1.42
6 in. to 9 in.	.42	1.42
9 in. to 12 in.	.43	1.44

The upper 6 in. of the old sand left in the filter averaged .53 mm. effective size and 1.35 uniformity coefficient.

Procedure Followed in Resanding

Removing Old Sand.—A few inches of sand was ejected from many of the filters by a high rate of wash, but the great bulk was removed, down to a point 38 in. below the top of the wash water trough, by shoveling into a sand ejector which received its water from a 180 g.p.m. centrifugal pump connected to the wash-water main. The sand and water was discharged through a 4-in. flanged pipe line, carried on stilts over the lawn, to the waste dump. The length of this discharge line ranged from 1,000 to 1,300 ft. Three laborers were used; two shoveled sand into the ejector and the third alternated with the others and assisted in attending the pump and in shifting the hose and ejector.

Screening the Sand.—A Tyler 2-surface inclined electric vibrating screener, with 4 ft. x 5 ft. screens was used. To get a satisfactory removal of fines, it was necessary to dry the sand completely. This was accom-

plished in a rotary sand dryer heated with two kerosene burners.

Washed Ohio River sand was delivered in trucks and dumped under a crude roof to avoid wetting by rain. It was hauled in 1-ton ash cars to the sand shed as needed. Here it was fed to a 24-ft. portable belt conveyor which elevated it into the screen house, where it passed through the dryer and to the hopper of the screener. The three fractions of the screenings, namely waste pebbles, waste fines and filter sand, were chuted into ash cars under the screen house.

Three laborers were used for the screening operation. One shoveled sand to the conveyor, one attended the screens and burners, and the third man was of general assistance, and relieved the others at times.

Three laborers were needed for hauling crude sand to the sand shed, filter sand to the storage filter, and waste material to the dump. They also were used to spread out sand in the storage filter or in such filters as were refilled by direct dumping from the cars.

For a top screen Tyler's No. 817 "Ton Cap" with elongated rectangular openings was used. This removes material of 1 mm. or larger diameter. Ohio River sand contains about 5 per cent of small pebbles, and after removing these the sand has an effective size of from .24 to .28 mm., with 1.75 as an average uniformity coefficient. From this filter sand of .33 mm. effective size and 1.55 uniformity coefficient was prepared by using a bottom screen of .013 inch diameter steel wire, 35 mesh and .384 mm. screen opening. This material, used in the first two filters, was too fine. The sand used in the other filters, averaging .37 mm. effective size and 1.46 uniformity coefficient, was produced with a bottom screen of .015-in. diameter steel wire, 30 mesh and .465 mm. screen opening.

Two top screens and two bottom screens wore out during the job. The average life of these screens was about 75 working days, during which time about 1,200 tons of sand had been dried and screened.

Refilling with New Sand.—The screened filter sand was hauled from the screen house in one-ton ash cars by the electric locomotive, and stored in an emptied filter just inside the door of the filter house. From here it was transported, by the ejector, to the filter which was being resanded. The sand was distributed in the filter through a 4-in. pipe, hanging downward, which had been split and bent so as to form a horizontal plate which deflected the outcoming water and sand in all directions. A few filters near the door were filled by direct dumping from the cars.

TABLE I—DATA ON REMOVING OLD SAND

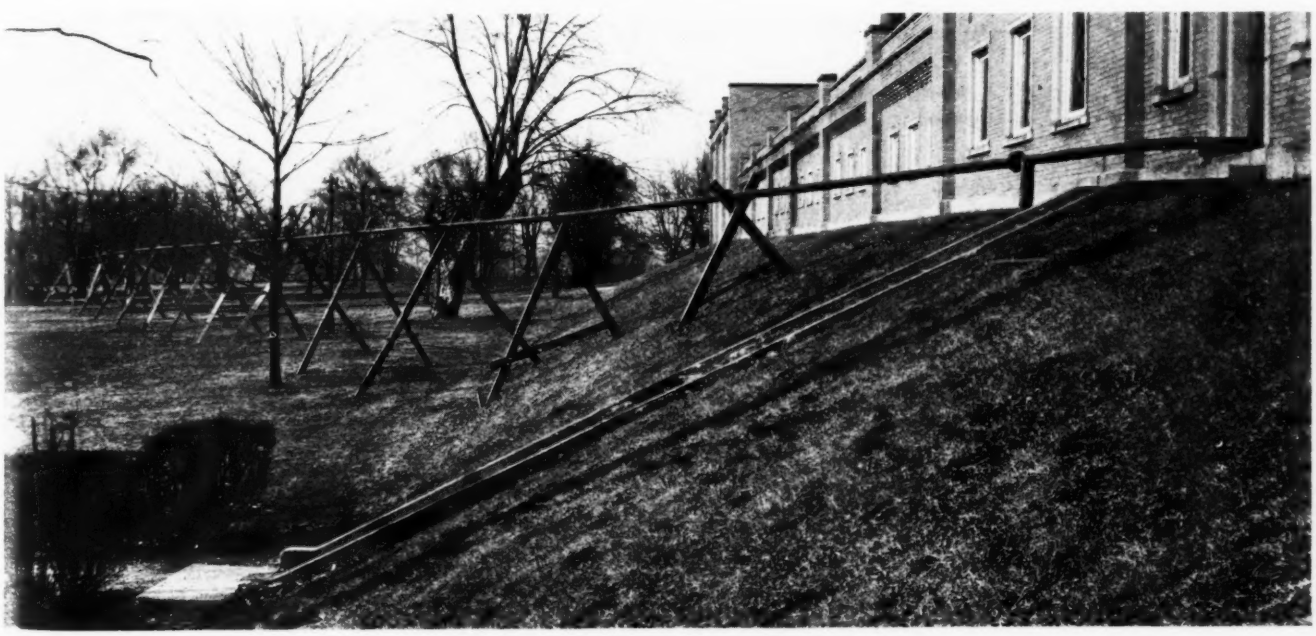
Average Depth of Old Sand Removed	25.5	in.
Volume Old Sand Removed—By High Wash	175.	cu. yd.
By Ejector	2,925.	cu. yd.
Total	3,100.	cu. yd.
Time Required to Eject 2,925 cu. yd. (8 Hour days)	151	days
Average amount ejected per hour	2.4	cu. yd.
Number Laborers Used for Ejecting Sand	3	
Cost of Labor—453 man-days at $3.80	$ 1,721.40	

Total Cost of Removing Old Sand

150 ft. 3-in. used pipe	$ 35.28
100 ft. 2½-in. fire hose	62.50
Miscellaneous fittings	22.14
Labor—placing pipes and preparatory work	90.75
Labor—ejecting sand as above	1,721.40
Supervision	172.50
Total	$ 2,704.57
Average Cost per Cu. Yd. Removed	$ 0.68
Average Cost per Filter (1,400 sq. ft. sand area)	75.16

In addition to the three men working at the ejector, a fourth laborer was needed to distribute properly the incoming sand. Also, two laborers were required to haul the sand from the screens to the storage filter, so that six laborers in all are charged to the refilling process.

After excavating old sand to the proper depth, about 13½ in. of new sand, as an average, were placed in the filters, so as to have a freeboard of about 25 in. The bed then was washed and filtered to waste for three 4-hour periods, with intervening washes. This wasting was necessary before reasonable bacterial removals were obtained. Thereafter, a shallow layer of top sand was scraped off in order to yield a final freeboard of 26 in. This scraping was not a necessary step and was not practiced on all filters. The principal reason for



4-In. Discharge Line from Sand Ejector

Sand Shed and Sand Screening House

the scraping was to remove flakes of coal which collected on the surface of the sand. Some deliveries of crude sand contained more coal than others.

Time, Tonnage and Cost Records.—These records are given in some detail in the Tables I, II, III and IV.

The sand beds were washed and leveled, by draining, before any measurements were made. From these measurements the volumes of sand removed or added were calculated. The dry filter sand weighed 100 lb. per cubic foot, but it was found that each cubic yard of the wet sand, as measured in the filter after draining, represented 2,500 lb. of dry sand. This figure accordingly is used for converting volume in the filter into its equivalent weight of dry sand.

TABLE II—DATA ON SCREENING SAND

Total Quantity of Crude Sand Screened	3,142 tons	
Wasted (Pebbles and Fine Sand)	1,131 tons	
Gross Quantity of Filter Sand Obtained	2,011 tons	1,609 cu. yd.
Filter Sand Wasted by Scraping Filters	157 tons	126 cu. yd.
Net Quantity of Filter Sand in Finished Filters	1,854 tons	1,483 cu. yd.
Net Yield of Filter Sand		59 per cent
Time Required to Obtain 2,011 Tons Filter Sand		175 days
Average Output of Filter Sand per day		11.5 tons
Number Laborers used for Screening Process		4
Cost of Labor—700 man-days at $3.80		$ 2,660.00

Total Cost of Screening Process

Building Screen House, complete except lumber	$ 782.30
W. S. Tyler Type 27 Screener	967.00
Three Top Screens	51.34
Three Bottom Screens	47.40
24 ft. Portable Conveyor and Motor	578.17
Sand Dryer, fuel tanks, 4 burners	400.00
Miscellaneous Repair Parts	58.42
Kerosene, 9,025 gals. at 9¾ cents	879.94
Labor for Screening, as above	2,660.00
Supervision	345.00
Total	$ 6,769.57
Cost of Screening, per net cu. yd. of new sand in Finished Filter	$ 4.56
Cost of Screening, per filter (1,400 sq. ft. Sand Area)	241.77

The resanding of the first filter was started in October, 1928, and the last filter was completed in April, 1930. The job was not rushed, however, and was suspended during the summer and at times when other work needed attention. Excepting the preliminary preparations, the entire resanding was completed within a total period of 175 working days.

The following regular plant equipment was used in the resanding, and is not included in the cost estimate —electric locomotive, six 1-ton ash cars, 1,500 ft. of industrial track, ties and switches, 1,300 ft. of 4-inch flanged pipe, 180 g.p.m. centrifugal pump, 3 hp. motor, sand ejector, and used lumber for the screen house and sheds. Power and water wastage also do not enter into the cost figures. Approximately 35 M. G. of filtered water were used for transporting the sand through the ejector and for washing the new beds. Also, 56 M. G. of treated water were wasted in cleansing the new filters before placing them in service.

During the first half of the work, three-fourths of the time of a capable power-plant engineer was given to supervising the operations. One-half of this supervision charge is assigned to the screening process, one-fourth to removing old sand, and one-fourth to refilling the filters.

Table IV shows the total cost of the resanding was $16,792.42; equivalent to $11.32 per cubic yard of new sand in the finished filter, or to a cost of practically $600.00 per filter.

The charging off of $2,000 worth of new equipment at its full purchase price makes the costs high. Except for the two screens, such equipment is in no way depreciated, and is available for similar work in the future.

Table IV shows $3.39 as the cost of the sand, and $4.56 as the cost of screening, or a total cost of $7.95 for sand and screening, per net cubic yard of new sand in the finished filter.

It is impossible to estimate the length of filter service that can be obtained from sand of a certain size, without an actual trial in the plant filter. In the preliminary estimates it seemed that sand of .34 mm. effective size would be satisfactory for a shallow resanding such as has been completed. As the work progressed, however, it was evident that a somewhat coarser sand was re-

quired. This reduced the yield from 75 per cent, for the finer product, to 59 per cent for the material which has been used. This reduction in yield is the main reason why the saving effected by screening the sand has not come up to earlier expectations. Another reason is that the crude Ohio River sand has contained more unsuitable fine material than was shown by the few samples on which the preliminary estimates were based.

With the present experiences fresh in mind, an expression of opinion which might be helpful in future filter construction is in order. This concerns the suitability of sand in the neighborhood of .37 mm. effective size, such as was used in the present work. It is based on the behavior of Filter No. 18, which, as mentioned earlier, had all of the old sand removed and then was filled with 30 in. of .37 mm. sand.

Twenty-five runs on this filter, operated to a 4.5 ft. loss of head, yielded an average service of 14 hours per run. This is only one-half the service given by the present partially resanded units (which contain only 12 in. of the .37 mm. sand) and only 35 per cent of the estimated service given by the old filters before resanding had started.

As the city grows, additional filters will have to be built at some time in the future. With new units available, the plant at that time will be operating considerably under its then rated capacity, so that rather short filter runs for a few years will be no serious handicap. Therefore it seems that .37 mm. sand, or slightly coarser material, might be suitable for such new filters.

On the other hand, the present filters at some time may require a complete resanding, as distinguished from the present partial reconstruction. If this is necessary before new filters have been built, then .37 mm. sand is too fine to yield adequate filter service, because in the absence of new units the plant in the future will be operating much closer to its rated capacity than it is doing at present.

TABLE III—DATA ON PLACING NEW SAND IN FILTERS

Average Depth New Sand Placed in Filters	13.3	in.
Average Depth New Sand Removed by Scraping	1.0	in.
Average Depth New Sand Remaining in Filter	12.3	in.
Total Quantity New Sand Placed in Filters	1,609	cu. yd.
Total Quantity New Sand Removed by Scraping	126	cu. yd.
Total Quantity New Sand in Finished Filter	1,483	cu. yd.
Time Required to Place 1,609 cu. yds. in Filters	58	days
Average quantity placed per day	27.7	cu. yd.
Number Laborers used, hauling sand to storage filter	2	
Number Laborers used, placing sand and scraping	4	
Cost of Labor, for hauling, 350 man-days at $3.80	$ 1,330.00	
Cost of Labor, placing sand and scraping, 270 man-days at $3.80	1,026.00	

Total Cost of Placing New Sand in Filters

150 ft. 3-in. used pipe	$ 35.28
100 ft. 2½-in. fire hose	62.50
Miscellaneous fittings	14.00
Labor—laying tracks and preparatory work, 66 man-days at $3.80	250.80
Labor—hauling sand as above	1,330.00
Labor—placing sand as above	1,026.00
Supervision	172.50
Total	$ 2,891.08
Average Cost per Cu. Yd. New Sand in Finished Filter	$ 1.95
Average Cost per Filter (1,400 sq. ft. sand area)	103.25

TABLE IV—RECAPITULATION OF COSTS

	Total Cost	Cost Per Cu. Yd. New Sand in Finished Filter	Cost Per Filter
Removing Old Sand (Table I)	$ 2,104.57	$ 1.42	$ 75.16
New Sand Purchased, 3,142 Tons at $1.60	5,027.20	3.39	179.54
Screening New Sand (Table II)	6,769.57	4.56	241.76
Placing New Sand (Table III)	2,891.08	1.95	103.27
Total	$16,792.42	$11.32	$599.73
Distributed as Follows—			
Sand	$ 5,027.20	$ 3.39	$179.54
New Equipment	2,043.91	1.38	73.00
Kerosene	879.94	.59	31.42
Other Supplies	396.90	.27	14.18
Labor	7,754.47	5.23	276.95
Supervision	690.00	.46	24.64
Total	$16,792.42	$11.32	$599.73

Public Water Supplies In Ohio

In a recent issue of the Engineering Experiment Station News of Ohio State University, F. H. Waring, Chief Engineer, Ohio Department of Health, gives the following information:

The 1930 census shows that Ohio, on April 1 last, had a population of 6,646,697, of which 4,760,761, or 71.7 per cent are provided with public water supplies. There are 110 cities and 288 villages which are provided with public water supplies. Of the 224 villages which have their own plants, 48 are between 2,500 and 5,000 in population, 103 are between 1,000 and 2,500, 61 are between 500 and 1,000 and 12 are less than 500 in population. There are 39 villages in the state, over 1,000 population, which are not provided with public water supplies.

Most of the municipalities supplied from adjacent cities are located near cities of large population, 10 cities and 31 villages being supplied by Cleveland, two cities and 12 villages by Cincinnati, and two cities and four villages by Columbus.

A total of 362 of the municipal water works systems are municipally owned while 36 systems are owned by private companies.

The total population supplied with water is about 4,750,000, of which 63.4 per cent is supplied with filtered water, 11.8 per cent with softened water, 11.9 per cent with chlorinated well water, 0.4 per cent with chlorinated surface water, 0.2 per cent with untreated surface water, 0.8 per cent with well water treated at iron removal plants and 11.5 per cent with untreated well water.

Of the 317 municipalities in the state which have their own plants, 77 use surface water and 240 use well water. However, by far the majority of the population is supplied by water from surface sources, 3,491,349 persons, or 73.3 per cent of the population, being so supplied, while 1,269,412 persons, or 26.7 per cent are supplied with ground water. This is due to the fact that most large cities have filtration plants while most of the villages use well water supplies.

THE DIESEL ENGINE IN MUNICIPAL PLANTS

By C. F. LAMBERT

Of Burns & McDonnell Engineering Co., Kansas City, Mo.

WITH few exceptions, isolated steam plants cannot compete in economy with large superpower plants, while in most cases Diesel plants can. This does not mean, however, that many moderate-sized steam plants are not being operated at a saving over the rates which are offered from the large plants because in many cases they are. Just where it becomes economical to install Diesel plants in preference to steam plants depends, of course, on many local conditions and varies widely. It is found that out of 34 projects, Diesel installations were recommended in 18 and steam plants in 16 of these. Of the 16 steam plants, the smallest output was 1,000,000 kw-hr. per year, the largest 98,000,000 kw-hr. per year, and the average 14,850,000 kw-hr. per year. Of the 18 Diesel plants, the smallest output was 1,000,000 kw-hr. per year, the largest 22,000,000 kw-hr. per year, and the average 5,000,000 kw-hr. Of the 16 steam plants 10 projects were enlargements of existing steam plants and six were new plants. Of the 18 Diesel plants, three were enlargements of existing Diesel plants, three were steam plants which were changed to Diesel plants, and 12 were new plants.

Relative Size of Plants.—A further comparison of the relative size of these plants is shown in Table I:

Of the two steam plants which had an output of 1,000,000 kw-hr., one was in a coal district where freight on oil made it prohibitive, and the other was primarily a steam-heating plant.

In another steam plant with an output of 1,500,000 kw-hr. the Diesel engine would have proven more economical in the long run, but there was already a steam plant in existence, with a good boiler plant. This made the first cost of the Diesel plant considerably in excess of the steam plant, and it was decided to maintain the steam plant. Of the two larger plants in which Diesel equipment was recommended, one had an output of 21,000,000 kw-hr., and the other an output of 22,000,000 kw-hr. One of the : plants was a standby plant for a hydo-electric plant a: l the other was to be started as a small plant and be g :dually enlarged, therefore, the Diesel plant was found o meet the requirements to best advantage.

These figures indica : that whenever a small plant goes to steam or a larg plant to Diesel operation, there is a special reason therefor. It is well known, of course, that to obtain the best economy from a steam plant it is necessary to install equipment which will utilize as much of the energy of the steam as possible. This includes economizers, air preheaters, superheaters, etc. It is necessary, also, to generate steam at high pressures. All of this equipment is expensive to install and maintain, and for the smaller plants, particularly where the load factor is low, the additional economy will not compensate for the extra cost of operation.

The great advantage of the Diesel engine lies in the fact that the fuel consumption per horsepower does not vary so greatly between partial loads and full-load capacity, nor does it vary so greatly between small units and large units. There is, also, the advantage of being able to throw a unit on the line at a moment's notice. This enables the engineer in designing his plant to adjust the number and size of the units according to the load without the great loss in economy which would occur in a similar steam plant.

Installation on Savings Basis.—Another factor which has entered largely into the development of the Diesel-engine municipal plant has been the willingness of many of the Diesel manufacturers to install their equipment on the savings basis. This sometimes takes the form of the installation of the equipment in an existing plant with no down payment or a small amount paid down, and the balance of the payments made out of the savings over the old operation. In cases where an entire new plant was desired, this was, of course, not so satisfactory. Engine builders naturally did not want to finance the construction of buildings and distribution systems, although in some cases even this has been done. In one case a complete electric-light plant, distribution system, water-works pumping plant, filter plant, and distributing extensions were financed in this way. Many states now have laws permitting the cities to issue bonds against the utility itself, without impairing the general bonding credit of the city. In some cases, this does not require a vote of the people. This has given great impetus to the construction, particularly, of the smaller plants which are largely Diesel plants.

In preparing reports on the feasibility of new plants, both steam and Diesel plants are included where the output is between 2,000,000 and 10,000,000 kw-hr. per year. There are many special cases with smaller and larger outputs where both types are considered. Usually those plants below 2,000,000 kw-hr. are unquestionably Diesel plants and those above 10,000,000 kw-hr. unquestionably steam plants. It will probably be interesting to see the comparison in first cost and operating cost as estimated on a number of projects. The two sets of figures under cost per kw-hr. show the plant operating cost, and the entire cost of operation including interest and depreciation on the new investment.

The reason that the starting and final kw-hr. output is given is that many of these plants would start as competitive plants only securing part of the business to start with. The fact that there would be a possibility, however, in time of their acquiring the entire load was in many cases an important factor in the final decision as to the type of equipment to be installed.

Basis of Recommendation.—In the preceding cases recommendation was made largely on the following basis:

TABLE I

	DIESEL		STEAM	
	No. of Plants	Ave. Output Millions Kw-hr.	No. of Plants	Ave. Output Millions Kw-hr.
1,000,000 kw-hr. output or less	3	1.0	2	1.0
Between 1,000,000 and 4,000,000 kw-hr.	11	2.5	4	2.87
Between 4,000,000 and 10,000,000 kw-hr.	2	8.25	4	6.75
Between 10,000,000 and 25,000,000 kw-hr.	2	21.5	5	19.8
Over 25,000,000 kw-hr.	0	.....	1	98.0

Plant 1. This was primarily a hydro-electric plant and the Diesel or steam plants were for standby only. The operation of the Diesel plant was cheaper and much more practical for this service.

Plant 2. There was very little difference in the first cost of the two plants and the Diesel plant was found to be much more economical.

Plant 3. This was adding an additional unit to a plant operating with gas engines. Gas engines were also considered, but found not so economical. One reason for the great difference in cost of the steam plant was due to changes required in the building, coal handling, machinery, etc.

Plant 4. This was a new plant and the figures showed without question the advisability of the Diesel plant. The steam-plant cost was increased somewhat due to difficulty in fuel handling during flood conditions.

Plant 5. Load conditions were such that 1500 kw. capacity was sufficient for the beginning of the operation, but in the case of the steam plant, it was thought advisable to install at least two 1000 kw. units. This added to the advantage of the Diesel plant, which already showed advantage in operation. The Diesel plant was recommended.

Plant 6. The first costs of the two plants in this case were almost identical. The operating cost showed a decided advantage in favor of the Diesel plant.

Plant 7. The first cost of this plant was in favor of the steam equipment, but the operating cost was decidedly in favor of Diesel equipment, which was recommended.

Plant 8. This project was an addition to an existing steam plant. The steam plant showed considerable saving in first cost, but the advantage of the Diesel plant in operation was evident, and a Diesel engine was installed.

Plant 9. This project was also an addition to an existing steam plant. In this case no new boiler was required and this accounts for the low cost of the steam plant. While the Diesel plant showed devided advantages in operation, the steam equipment was installed largely due to the factor of first cost.

Plant 10. This project showed advantages in using the Diesel engine due to the plan of extension which was planned.

Plant 11. This plant was located in a place of comparatively cheap coal and high freight rates, and the Diesel plant was out of the question.

Plant 12. The Diesel plant had the advantage of the possibility of smaller units to start with and, therefore, a lower first cost. There were also, economies in operation. However, due largely to local conditions, a steam plant was decided on.

Plant 13. This was an addition to an existing steam plant and included some steam heating. The steam equipment therefore showed economies over the Diesel, and steam was recommended.

Plant 14. This plant was so obviously a Diesel plant that steam was not considered.

Plant 15. The Diesel plant was slightly higher in first cost. The final cost per kw-hr. was almost exactly the same. Due to the size of the plant and local fuel conditions, the steam plant was recommended.

Fuel Consumption.—One advantage of the Diesel engine is that the fuel consumption per kw-hr. does not vary so greatly between small loads and full load. At a recent letting, the following guarantees (Table III) were offered by various engine builders on about a 1000-hp. engine in pounds of fuel oil per kw-hr.

The important point to a city intending to purchase engines is: What will be the actual operating economy of the plant as a whole? This will, of course, depend on the load factor. Actual examples will give the most accurate answer.

The Ponca City Plant.—Ponca City has one of the outstanding Diesel plants operated by a municipality. There are four 1250 hp. Nordberg engines. No. 1 and No. 2 were installed in 1928, No. 3 was installed in

TABLE II—COMPARATIVE INSTALLATION COSTS

			DIESEL PLANT			STEAM PLANT		
Project	Output M'l'n Kw-hr. Start.	Final	Installed Capac. Kw.	First Cost	Cost Per Kw-hr.	Installed Capac. Kw.	First Cost	Plant Cost Per Kw-hr.
1	1.0	1.0	7,000	$925,000	1.30	7,000	$717,700	1.37
					1.47			1.65
2	10.0	15.0	4,000	562,850	0.85	4,000	560,170	1.03
					3.02			3.81
3	2.0	3.0	500	69,280	1.10	500	148,145	1.21
					3.47			3.95
4	2.5	5.5	2,000	280,000	0.89	2,000	320,000	1.10
					2.43			2.69
5	3.7	7.8	1,500	233,000	0.82	2,000	267,000	.98
					1.58			2.01
6	3.9	7.6	2,000	239,497	0.79	2,000	239,357	1.04
					3.80			4.4
7	2.0	3.0	1,250	219,000	1.22	1,250	194,800	1.91
					4.1			4.65
8	0.9	1.5	500	77,470	1.74	500	57,435	2.00
					1.58			2.01
9	1.5	2.5	500	68,930	1.15	500	37,162	1.77
					1.95			2.16
10	6.0	22.0	3,000	465,000	0.68	3,000	469,000	0.90
					4.10			3.75
11	1.0	1.5	650	100,000	3.21	650	121,650	2.7
					2.55			2.80
12	4.0	8.0	3,150	310,440	0.80	4,000	363,950	0.94
					2.93			2.75
13	3.8	6.0	1,500	202,750	1.50	1,500	220,750	1.26
					1.33			.....
14	2.2	3.5	1,250	214,005	0.92	.....	.....	.....
					2.74			2.75
15	7.5	15.0	4,000	462,700	0.66	4,000	427,650	0.72

TABLE III

	1	2	3	4	5	6	7
½ load	0.68	0.69	0.81	0.71	0.71	0.70	0.695
¾ load	0.62	0.63	0.71	0.66	0.626	0.635	0.635
Full load	0.62	0.63	0.67	0.645	0.607	0.605	0.60

Translated into kw-hr. per gallon of fuel oil this would read as follows (Table IV):

TABLE IV

	1	2	3	4	5	6	7
½ load	11.0	10.9	9.3	10.6	10.6	10.7	10.8
¾ load	12.1	11.9	10.6	11.4	12.0	11.8	11.8
Full load	12.1	11.9	11.2	11.6	12.4	12.4	12.5

TABLE V

1929 Units	Hours Run	Kw-hr. Produced	Kw-hr. Per Gal. Fuel Oil	Kw-hr. Per Gal. Lub. Oil	Average Kw.
1	6,027	3,345,700	10.062	3,130	555
2	6,992	3,862,700	10.42	2,810	552
3	1,899	969,650	9.05	1,498	510
4	764	454,900	9.55	1,736	595
Total	15,682	8,632,960	9.77	2,292	551

1930 Units	Hours Run	Kw-hr. Produced	Kw-hr. Per Gal. Fuel Oil	Kw-hr. Per Gal. Lub. Oil	Average Kw.
1	5,524	2,991,500	10.42	2,460	541
2	5,665	3,257,400	10.78	1,890	575
3	2,940	1,725,400	10.0	2,074	587
4	964	551,500	10.0	983	572
Total	15,097	8,525,800	10.3	1,852	564

Lubricating oil average cost 1929–30..... 52.7 cents per gal.
Fuel oil average cost 1929 ..... 2.15 cents per gal.
Fuel oil average cost 1930 ..... 1.7 cents per gal.

1926 and No. 4 in 1925. Table V shows the fuel-oil and lubricating-oil consumption for 1929 and 1930.

The maintenance cost during 1930 was 0.51 mills per kw-hr. The total plant operating cost was 0.5975 cents or practically 0.6 cents per kw-hr.

La Crosse, Kan., Plant.—La Crosse, Kan., has two small De La Vergne engines and one of 330 hp. Records for the past ten years show the following operation:

Year	Kw-hr. Produced	Kw-hr. Per Gal. Fuel Oil	Kw-hr. Per Gal. Lub. Oil
1921	381,548	9.0	1,170
1922	407,568	9.3	1,050
1923	457,887	9.8	1,225
1924	515,453	10.4	1,150
1925	536,106	10.1	1,160
1926	589,890	9.6	925
1927	583,141	9.7	820
1928	629,936	8.7	950
1929	791,568	9.8	710
1930	864,926	10.25	618
Total	5,758,023	9.67	

The kw-hr. per gal. of fuel oil for all years except 1930 includes oil used as fuel for station and office heating. The repairs and supplies for 10 years have averaged 0.43 mills per kw-hr. The total operating cost for the plant and distribution system has averaged 1.21 cents for the 10 years and 0.81 cents for 1930.

Results at Six Plants.—The following are results obtained in a number of plants with Busch Sulzer engines:

Town	Annual Kw-hr. Produced	Kw-hr. Per Gal. Fuel Oil	Kw-hr. Per Gal. Lub. Oil	Maint. Per Kw-hr.
McMinnville, Ore.	2,820,800	10.5	3,000	
Opelousas, La.	1,724,830	10.325	1,074	$0.00007
Duncan, Okla.	2,096,300	10.55	951	0.00083
Madison, S. Dak.	1,955,080	11.26	855	0.00042
Bryan, Tex.	2,473,439	10.55	1,150	0.000483
Baldwin City, Kan.	503,650	11.11	760	0.001380

The Higginsville, Mo., Plant.—Higginsville, Mo., a city located in a coal region, has found it profitable to install Diesel engines. They have four Fairbanks-Morse units totaling 2000 hp. Their results for the past four years have been as follows:

Year	Annual Kw-hr. Produced	Kw-hr. Per Gal. Fuel Oil	Kw-hr. Per Gal. Lub. Oil	Maint. Per Kw-hr.
1926	729,762	8.44	540	$0.000414
1927	883,879	8.65	585	0.000462
1928	1,187,493	9.02	500	0.000785
1929	1,733,400	10.3	850	0.000374

St. Petersburg, Fla., has four McIntosh & Seymour units totaling 4450 hp. The results for one year were as follows:

Kw-hr. output	8,667,825
Kw-hr. per gal fuel oil	11.575
Kw-hr. per gal. lubricating oil	5,400
Maintenance per kw-hr.	0.000302

Hudson, Mass., with McIntosh & Seymour engines and an annual output of about 3,000,000 kw-hr. showed an average of 11.91 kw-hr. per gal. of fuel oil.

Several Iowa cities with Fulton engines showed the following results:

Town	Annual Kw-hr. Produced	Kw-hr. Per Gal. Fuel Oil	Kw-hr. Per Gal. Lub. Oil	Maint. Per Kw-hr.
Greenfield	1,081,899	10.79	1,019	$0.00045
Harlan	1,710,500	11.02	1,850	0.00011
Hawarden	1,012,775	9.4	1,290	.....

Horton, Kan., with 1560 hp. in Worthington engines, shows the following results:

Kw-hr. output	2,099,100
Kw-hr. per gal. fuel oil	9.85
Kw-hr. per gal. lubricating oil	2,182

All of these plants and many others have shown good earning capacity.

Acknowledgment.—The foregoing is a paper presented at the National Oil and Gas Power Meeting, Madison Wis., June 24 to 26, 1931, of The American Society of Mechanical Engineers.

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Large Artesian Well

According to the April issue of *New Mexico Highway Journal* the Oasis Cotton Co., of Roswell, N. Mex., completed a well last February that has a flow of 20.55 cu. ft. of water per second. The well was drilled for the company by Myron S. Bruning of Artesia and is located in the SE ¼ of SW ¼ of Section 15, Township 11 South, Range 25 East, in what is commonly termed the Roswell Artesian Basin. This basin, covering some 272,000 acres of land, supplies irrigation water to about 57,000 acres of land. Along the western margin pumping is necessary but toward the east hydrostatic pressure is sufficient to force water well above the surface. Most of the wells drilled into the basin prior to 1900 encountered pressures which threw the water high above the casing of the completed well, but many have since ceased to flow.

Due to the great number of wells which have been drilled into the basin in the last 30 years, something over 1,500, the water level has been lowered in places more than 200 ft. Wasting of water, through faulty construction and casing of wells, has given a further impetus to the decline of the water table, until a great many users of water have been forced to pump from wells which 30 years ago flowed freely. The new well of the Oasis Cotton Co., which was drilled to a depth of 843 ft., however, encountered pressure sufficient to force the water 50 ft. into the air through a 6-in. nipple on a 12½-in. casing.

The water supply from the new well will be used for the irrigation of some 1,450 acres of land lying in the Oasis farm, in conjunction with numerous other wells of the company.

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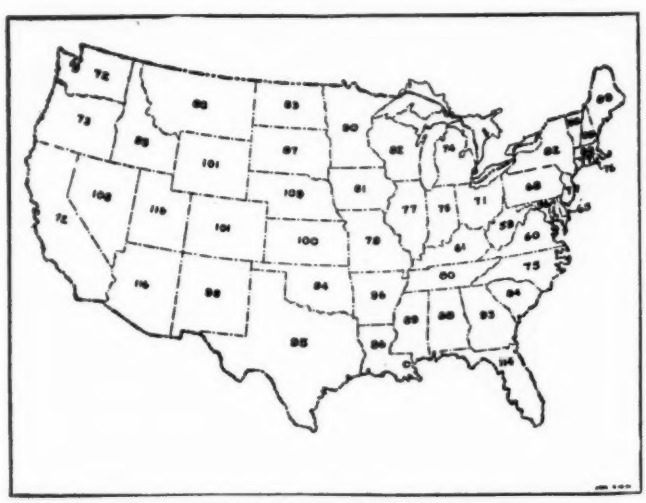

Percentage of Normal Rainfall in 1930

The above chart shows the percentage of normal precipitation received in the United States in the drought year of 1930. It is taken from a University of Iowa Extension Bulletin, prepared by Prof. Floyd A. Nagler.

EDITORIALS

Cycle Changes in Lake Levels

IN *Monthly Weather Review*, March, 1931, there is a very interesting article entitled "Notes on Lake Levels," by Jesse W. Schurman, C. E. Mr. Schurman summarizes Bruckner's data published about 40 years ago, and gives additional facts together with a discussion of the "Wolf cycle," the "Buckner cycle" and the "secular cycle." He adopts the cycle nomenclature that Streiff has used. Since there are fully 10 times as many weather cycles as Streiff has discussed, it follows that his nomenclature will soon be abandoned. There is, for example, no such thing as "the secular cycle" of weather, meaning a very long cycle, for there are at least a dozen secular cycles.

Streiff has attempted to show that Bruckner erred in his inference that there is a weather cycle whose mean length is about 35 years. Streiff believes that Bruckner confused the peaks of "the secular cycle" (which Streiff regards at 60 to 90 years long) with the peaks of a cycle whose length is double the sunspot cycle, or $2\times11.2=22.4$ years. However, a careful review of the peak and valley dates of the Bruckner cycle fails to support Streiff's conclusions, There is unquestionably a weather cycle of 22.4 years, but the editor has conclusively established the existence of a cycle of 31.5 years. The peaks of this latter cycle fall near the last three peaks of lake levels given by Bruckner, namely 1820, 1850 and 1880 A. D. In his earliest writings Bruckner regarded his cycle as being 32 years. Later he concluded that it ranged in length from 20 to 50 years. Streiff is right in concluding that Bruckner confused the peaks of entirely different cycles, but is wrong in inferring that Bruckner's cycle is 22.4 years.

The 31.5 year cycle is ⅛ of 252 years, and is a subcycle due to the planet Pluto whose last cycle peak was in 1848, and whose previous cycle peak was in 1596. By cyclogram analysis of the thickness of sequoia tree-rings and of annual clay varves, the editor has established the existence of a 252-year cycle. Harmonic therewith is a cycle of 31.5 years. Since the peak dates of the latter correspond closely with the lake level peaks of 1820, 1850 and 1880, which Bruckner regarded as peaks of his cycle, there is little doubt that the Bruckner cycle is a subcycle due to the planet Pluto.

Bruckner's first two lake level peaks were in 1740 and 1780. The last named date is very near the sunspot and rain peak of 1778, which the editor has assigned to an invisible planet that causes a weather cycle of 316 years in the sequoias and the clay varves. There were peaks of the 22.4-year cycle in 1783, and in 1738.

It is no simple matter to explain certain lake-level and rainfall peaks even when one knows the lengths of each of 40 weather cycles, for the complexity of the problem is very great. At present the best that can be done is to indicate some of the outstanding cycles being those that probably were the most instrumental in producing certain precipitation peaks. For example, Lake Ontario was very high in 1838. The planet Neptune (whose cycles are 161 years) caused a sunspot peak in 1837, so it is likely that it was largely responsible for the rise of Lake Ontario to the peak level of 1838. Great Salt Lake was very high in 1870, and that was the time of a great sunspot peak due to Uranus, whose cycles are 81 years.

Due to differences in the earth's magnetic fields at different places, there are striking differences in weather at the same time in different areas under the influence of the very same magnetic field of a planet. Much remains to be done before these local differences in weather will be fully understood.

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Is the Moon's Interior Molten and Rotating?

AT last man has discovered a means of "sounding the atmosphere" without sending up balloons or other devices. Radio waves are reflected from electrified strata very much as sound waves are reflected from solid walls. By timing radio echoes and by observing the places where radio reception is clearest, not a little has been learned as to the altitude and nature of electrified strata.

At a recent meeting of the American Institute of Electrical Engineers Dr. Harlan T. Stetson stated that the strength of radio signals between Boston and Chicago averaged about 100 per cent greater when the moon was below the horizon than when it was visible. This led him to the inference that the moon is negatively charged and emits electrons whose bombardment lowers the Kennelly-Heaviside layer of electrons in our upper atmosphere. A lowering of that radio ceiling shortens the distance of travel of the radio waves and increases the number of reflections. Since each reflection is accompanied by a loss of energy, the clarity of radio signals decreases as the distance between the earth and the Kennelly-Heaviside layer decreases.

In WATER WORKS AND SEWERAGE, December, 1930, the editor stated that he had found an Alaskan rainfall cycle of 27.32 days, which is the length of the sidereal or true period of revolution of the moon about the earth. Since this rain cycle is explainable only on the hypothesis that the moon is magnetic, it follows either that the moon contains a molten interior that is electrically charged and rapidly rotating or that a rotating shell of electrons surrounds the moon. In either case there would result a magnetic tide in the Kennelly-Heaviside layer, and that layer would be most depressed when the moon is most nearly overhead. Hence it is not necessary to assume that the moon emits electrons that bombard our atmosphere, for Ampere's law that oppositely moving electric currents repel one an-

other suffices to explain these phenomena if either the moon's interior or an external electron shell is rotating.

In WATER WORKS AND SEWERAGE, November, 1930, the editor explained the semidurnal cycle of the barometer by applying Ampere's law, in the same manner that the lunar effect on radio transmission is explained above. It is well known that radio transmission is best near midnight and poorest near midday. This follows inevitably from the theory above outlined. Hitherto it has been explained by assuming that the sun bombards the earth with electrons, whose depressing effect on the Kennelly-Heaviside layer is presumed to be greatest at noon.

Larry Page, statistician of the Research Bureau of Wallace's Farmer, read a paper, May 2, 1931, before the Iowa Academy of Sciences, in which he said that he had found that the moon causes a temperature cycle. In Iowa the lowest points in the temperature occur, on the average, when the moon is farthest below the ecliptic. This is every 27.21 days. The editor has made a 27.21-day cyclogram of rainfall at Juneau, Alaska, and has found not only a cycle of 27.21 days but one of one-third thereof, or 9.07 days. Moreover he saw that 250 times the rain cycle is so nearly equal to 249 times the previously discovered rain cycle of 29.32 days as to lead to the conclusion that they are probably harmonic. This inference was confirmed by means of a cyclogram analysis of monthly rainfall at Sitka, Alaska, for it disclosed a cycle of

249×27.32166 (sidereal period) $= 680.3093$ days $=$ 22.351 mos.

This is the length of the lunar supercycle, and there is also a semi-supercycle of rain, or one of 11.175 months.

Meteorologists have frequently commented upon a rainfall cycle of about 11 months, which is occasionally very marked.

Perhaps the most surprising inference to be drawn from this evidence of the moon's magnetism is that the interior of the moon is still molten and rotating rapidly. Since the moon's crust is not rotating with respect to the earth, it follows that if the entire moon were not rotating with respect to the earth, it could not produce magnetic tides in the Kennelly-Heaviside layer. Since the existence of such tides has been made evident by radio transmission, it is probable that the interior of the moon is rotating rapidly. But to rotate it must be fluid.

A viscous shell surrounding a molten globe would yield somewhat slowly to tidal waves of the molten matter. Hence the hydrostatic pressure on the front of the tidal wave, would exceed that on the rear. This would cause a rearward flow of the molten matter, or eddy, beneath the crust; and the resulting friction would reduce the rotative velocity of the crust. In the case of the moon this friction has completely stopped the rotation of the crust relative to the earth. In the case of the earth it follows that the crust is rotating less rapidly than the molten interior. Since the crust floats like an iceberg, it follows that the western faces of both the American continents receive greater frictional pressures from the molten core than any other parts of those continents. This explains, in part, the great continental uplifts on the Pacific Coast.

H. P. Gillette

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Tomorrow's Business Power or the Economics of "Standards"

AS the present conditions in business have shown, one of the best forms of security for capital invested in industry is scientific research. Discoveries of points of law, principle, and fact in natural phenomena today inevitably lead to their practical application in business tomorrow. How does industry advance if not by the application of invention and research to manufacturing methods? American industrial enterprise has enjoyed an envious evolution. This is plainly evidenced by the groups of technicians and industrialists sent by foreign nations to our shores to study American methods. The slow process of evolution of industry by improvements in mechanical equipment has given way to revolution of manufacturing processes by research. Witness radio and commercial air transport—twentieth century developments. It must be fairly admitted that science and research are a power in American industry today.

While a few discoveries are made in schools and laboratories of purely scientific nature, by far the greater number are made in industrial or commercial testing laboratories. In this work, members of the American Society for Testing Materials take a front seat. The acquiring of knowledge of materials and the development of standard specifications and methods of testing to determine if a material conforms with those standard specifications are powerful influences which underlie our national economic relationships.

In most cases the manufacturer has analyzed and tested his products to determine the uses to which they may be put. The consumer has also tested them to see if they will serve his purpose. Together through the activities of the A. S. T. M., engineers, scientists, chemists, metallurgists in producer and consumer organizations have developed a "standards" to measure the suitability of materials for specific uses and to serve acceptably as descriptions of materials in a contract between the producer and the consumer.

Viewed from another angle, the work of this organization may be termed the balance wheel of business enterprise—construction, manufacture, and production. The "standards" developed define a commodity to such a close degree that exchange of that commodity for some other may be done with a full knowledge of the practicability and limitations of both. Known qualities of materials may be balanced one against the other before a transaction is consummated, thus eliminating the factor of doubt and leaving the transaction entirely in the realm of a business dealing.

H. S. Rowe

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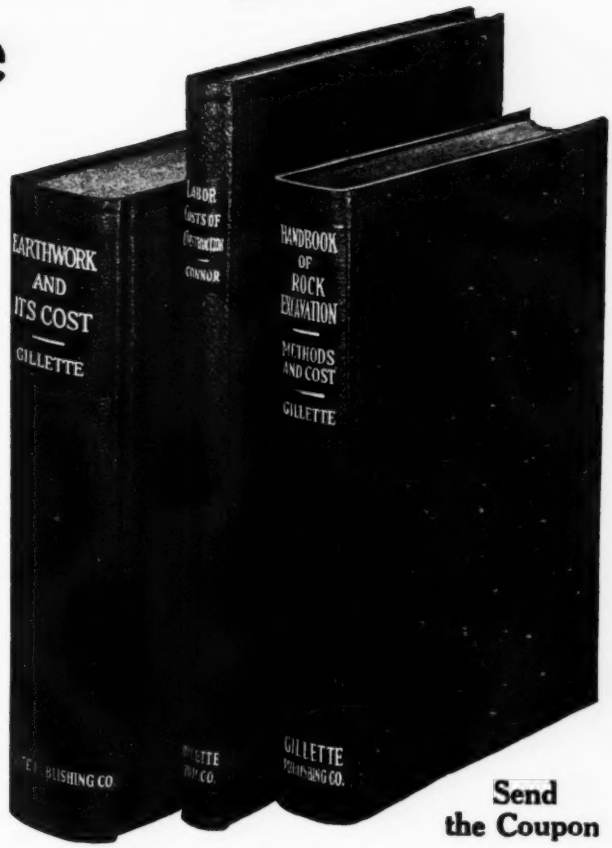

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NOTES FROM THE FIELD

City Departments of Dallas, Tex., to Pay for Water.—Members of the Park Board of Dallas, Tex., have agreed with John N. Edy, city manager, that the park department and other city departments should pay for water used from the city's supply system. Heretofore the park department and the fire department have used water without charge, the park department's consumption being especially heavy. While a rate was not agreed upon, it may be as low as 5 ct. per 1,000 gal. Manager Edy said that the fire department budget was to carry an appropriation of $15 per hydrant for water used by the fire department, this amounting to about $19,000 a year.

Renewal Clause in New Jersey Water Grants Dropped.—The State Water Policy Commission of New Jersey has decided that in the future the duration of grants to private water companies will be 30 years. In the past such grants were made for 30 years, with an automatic 20-year renewal clause. Such a grant, the commission concluded, was not good public policy.

Plans for Illinois Swimming Pools Must Be Approved by State Board.—The governor of Illinois has signed the bill providing that no swimming pools shall be built after Oct. 1, 1931, unless the state department of public health approves plans. The bill authorizes the department to prescribe rules for sanitary operation of pools.

National Water Works Co. Plan Declared Operative.—The plan for exchange of the common and preferred stock and debenture bonds of the National Water Works corporation for stock and bonds of the recently formed Delaware Valley Utilities Company has been declared operative, it was announced by the committee of security holders of National Water Works that more than 75 per cent of all classes of outstanding stock has been deposited with the committee's depositary. It is stated also that more than 70 per cent of the debentures have been deposited.

Decision Deferred on Application of Elizabethtown Water Co. for New Supply.—At a meeting of the State Water Policy Commission of New Jersey on July 8 decision was again deferred on the application of the Elizabethtown Water Co. for permission to exercise the right of eminent domain, under an act passed this year. The company is seeking to condemn such water rights as it may need to divert 20,000,000 gal. daily from a point near the junction of the Raritan and Millstone Rivers in Somerset County. The State Board of Conservation and Development, predecessor of the commission, issued a grant in 1918 permitting the Elizabethtown company to develop a supply of 20,000,000 gal. at that point. The question was referred to a committee to confer with President Charles I. Lafferty of the State Board of Health to determine whether there should be a general conference at which interests from both above and below the intake of the Elizabethtown company should be heard.

High Pumpage Record for Kenosha, Wis.—The highest pumpage of water by the waterworks in its history was recorded between June 29 and July 2, according to Peter J. Hurtgen, director of the department. A total of 36,296,259 gal. was pumped for the city, averaging over 9,000,000 gal. a day.

Property Owner to Finance New Mains in Undeveloped Part of Akron, O.—The city council of Akron, O., has adopted a new plan for securing payment for water mains laid in undeveloped parts of the city. The plan calls for assessment at the rate of 85 ct. a front foot against property on streets in which new service mains are laid, the assessment to be rebated in the form of free water when the street is so built up that the annual water rentals pay carrying charges on the money invested in the main. The new plan will affect property owners along 21 miles of new mains. The vacant lot owner now will actually finance laying the mains that benefit his property, but will be reimbursed when his lot is built upon and when he becomes a city water department patron.

Oakland, Calif., Has $20,000 City Manager.—Ossian E. Carr, for the past 17 years in the city managership field, became city manager of Oakland, Calif., on July 1 at a salary of $20,000 per year. Mr. Carr became city manager of Cadillac, Mich., in 1914; he then was succesively city manager of Niagara Falls, N. Y., Springfield, O., and Dubuque, Ia. He has been city manager of Fort Worth, Tex., since 1925.

Ohio Well Hits Prehistoric Pine.—The State Department of Health of Ohio, which is drilling wells in the drought area counties, brought in its first well early in July at Mound Crossing. This drilled to 65 ft. with a 4-in. casing, came in well over the top and flooded considerable territory. An interesting feature is that when water was first struck, there began to float to the surface large pieces of prehistoric pine—not fossilized—but a true pitch pine, coated with clay and found under the shale. According to *Ohio Health News* the pine probably dates at least to the glacial age and demonstrates the presence there in Ohio of the southern pitch pine.

New Heat Digestion Tanks Placed in Service at Chicago.—What is stated to be the first battery of heat digestion sewage tanks to be installed in the United States and the second on the American continent was placed in operation July 20 by the Sanitary District of Chicago. The digestion tanks have been in the process of installation at the west side sewage treatment plant since Feb. 1 and cost approximately $200,000. They will serve largely as experimental units at the present time, because the battery of three Imhoff tanks, of which two are now in use, will care for 1,800,000 people. At the present time a similar plant is in operation in Toronto and another under construction at Peoria. It is said the Calumet disposal plant, which when completed will care for the domestic sewage of a population of 450,000, will be entirely equipped with the new type of tank if experiments are satisfactory.

WATER WORKS AND SEWERAGE

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RESULTS OF TASTE AND ODOR CONTROL WITH AMMONIA-CHLORINE TREATMENT

By E. C. GOEHRING

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THE Beaver Valley Water Co. of Beaver Falls, Pa., operates two plants within three miles of each other on the Beaver River, which pump into different systems. The ammonia-chlorine treatment was installed at one plant, while the other was operated as before. This scheme made it possible to make direct observations of the merits of the ammonia-chlorine process using various points of application of the ammonia and the chlorine, as well as a wide range of ratios of chlorine to ammonia, to determine the effectiveness of taste and odor control, and other observations, such as the quality of sterilization with two different systems.

Observations and Conclusions.—From March, 1930, until October, 1930, the observations and subsequent conclusions drawn are as follows:

1. The ammonia treated water was far more palatable.

2. Earthy, musty, and fishy tastes and odors were entirely eliminated with the ammonia treatment; while the plant operating without ammonia produced water which had these tastes present.

3. Residual chlorine tests were found in all parts of the system using ammonia treated water; whereas in the other system no residuals could be found except close to the plant.

4. Aftergrowths in the reservoirs on the ammonia treated water system were absent; while in the other reservoirs with the normally treated water, occasional aftergrowths were found. The same applied to algae growths in the reservoirs of the two systems, none being found in the ammonia-treated water.

5. With equal chlorined dosages, higher residual chlorine values could be maintained in the ammonia-treated system without the formation of chlorinous tastes and odors. In the other system, it was necessary to maintain a residual within a much narrower range in order to prevent appearance of chlorinous tastes and odors.

6. In the ammonia treated water it was found necessary to allow a longer contact time for complete sterilization before the water left the plant. With two hours available contact time in the clear well it was found necessary to carry 0.20 ppm residual chlorine in order to completely sterilize the water in this period. The period contact required varied with the amounts of ammonia used; ie, the more ammonia for the same chlorine the slower the sterilization. The time for complete sterilization also varied with the p-H of the water; ie, the higher p-H value, the slower the sterilization rate. In the other plant, with chlorine alone, 15 minutes was sufficient to sterilize the water with the same chlorine dosage.

7. By applying the ammonia-chlorine treatment to the raw water, algae conditions, which developed on the filters and sedimentation basin walls, were completely removed and controlled without taste formation. At the other plant without ammonia, prechlorination of the raw water was equally effective in removing algae, but with a slightly higher chlorine consumption. The production of taste from the algae oils was at times noticeable, however.

8. No exact ratio of chlorine to ammonia is applicable under all raw water conditions. Ratios of chlorine to ammonia had to be changed from as low as

1 cl. to 0.3 NH3 to as high as 1 cl. to 1 NH3 to gain the desired results.

9. A rather unusual observation made during this period on the two distribution systems brought out the fact that the ammonia-treated water assisted in removcrenothrix growths in the pipe lines. After a few months operation, hydrant flushings required longer runs to clear the lines, but after several flushings, a much shorter run was necessary to clear the water. In the other system, no change in hydrant flushing was noticed.

10. It was found best to apply the ammonia and chlorine to the raw water, the ammonia first, and as soon as a *thorough mix* had been obtained to add the chlorine.

Due to the favorable results obtained at the one plant with the ammonia treatment, an ammoniator was installed at the other plant. With this layout it was possible to operate each plant with ammonia and vary the dosages and ratio of chlorine to ammonia, as well as to compare various points of application at each plant, in order to determine their relative effectiveness.

During the months of November, 1930, to June, 1931, both plants were operated with the ammonia treatment. During this time four "phenol" spills into Beaver River of varying intensities were encountered. These were real by-product "phenol" compounds from the Youngstown, O., area. Observations and conclusions during this period of severe phenolic taste and odor conditions are as follows:

1. With phenols present, the ammonia-chlorine treatment should be applied to either the settled water going to the filters, or where sufficient contact time is available, then directly to the filter effluent entering the clear-well.

2. Ammonia-chlorine treatment will not remove "phenols." It merely eliminates or materially reduces the production of chlor-phenols which create the bad tastes.

3. Ratios of chlorine to ammonia as high as 1 cl. to NH3 were ineffective in eliminating phenolic tastes under severe conditions.

Other observations made during the past 16 months of ammoniation are as follows:

1. The points of application of the ammonia and chlorine should not be too far apart. 2. Losses of ammonia of from 5 to 25 per cent were found in passing through a four hour sedimentation basin. 3. Reduction of from 40 to 60 per cent in free ammonia took place through the filters. 4. As soon as the chlorine was added to the raw or influent water to the filters shortly after the ammonia, these reductions dropped to the insignificant values, with a resulting ammonia saving.

Acknowledgement.—The foregoing is an abstract by the author of a paper he presented May 27 at the annual convention of the American Water Works Association.

NOTE: In our case it has been observed that with every recurrence of the phenolic taste and odor there is found a marked decrease in the p-H value of the raw water—often at pH 6.0. The normal chlorides are usually higher, and manganese is always present. These three factors are, we believe, directly responsible for our failure to eliminate phenolic tastes. It seems that some reactions in the stream were responsible for production of chlor-phenolic compounds in the raw water and it has been well demonstrated that once the chlor-phenol taste has been produced ammoniation will not eliminate the trouble. The taste of the unchlorinated water was already distinctly chlor-phenolic.

Water Wastes Reduced By Metering

Installation of meters at Ironton, O., not only reduced the per capita consumption from 207 gal. per day to 66 gal. but also eliminated the necessity of enlarging the pumping and purification plants. E. T. Edwards, Superintendent of Filtration at Ironton, tells about this in a discussion presented at the 10th annual Ohio Conference on Water Purification. His statement was as follows:

At the time the water purification plant was installed in 1920 water consumption averaged for the year 2.9 mgd. Very much higher rates were experienced during certain periods, when the pumps and the purification plant were strained to the utmost to meet the demand. For a population of 14,000 this represented a per capita daily use of water of somewhat over 200 gal.

At that time considerable difficulty was experienced with sand in the river water cutting the packing and the valves of the reciprocating pumps. It was necessary to spend several hours every day in overhauling the pumps which had a total capacity of 4 mgd. It became apparent that either the pumping capacity must be increased or what seemed to be more sensible, the services must be metered in order to decrease the consumption. The industrial depression of 1921 tended to reduce consumption somewhat but even then peak demands were almost more than the plant could supply.

In 1922 the metering of the system began. It was practically completed in 1923. In the table below the average daily consumption for the past ten years is shown. The population served has increased during this period from 14,000 to 16,600. The consumption has been reduced from 200 gal. per capita to 66 gal. per capita daily.

The metering of this supply has prevented the necessity of enlarging the pumping and purification plants which would have been necessary if consumption had continued at the same rate per capita which obtained in 1920.

Average Daily Consumption of Water at Ironton During the Past Decade

Date	Gallons per Day	Per Capita Consumption Gallons per Day
1920	2,900,000	207
1921	2,616,000	.....
1922	2,420,000	.....
1923	1,879,000	.....
1924	1,189,000	.....
1925	1,159,000	.....
1926	908,000	.....
1927	889,000	.....
1928	945,000	.....
1929	1,046,000	.....
1930	1,098,000	66

AMERICAN ENGINEER TO REPORT ON SHANGHAI WATER SUPPLY.—In behalf of the Shanghai Municipal Council, a study of the Shanghai water supply will be made by Nicholas S. Hill, Jr., of New York, president of the Hackensack Water Co., and internationally known engineer. Mr. Hill's inquiry will deal particularly with the financial administration of the Shanghai Water Works, an English owned company. A protest by the Chinese Ratepayers' Association against an increase in water rates in the International Settlement resulted in agitation which did not cease until the Shanghai Municipal authorities agreed to summon an American expert. Mr. Hill's report is expected to provide a basis for determining whether the water works are being economically administered.

Pump House at Left; Imhoff Tank (Screened Over) Aeration Tank and Final Settling Tank

THE TREATMENT AND DISPOSAL OF SEWAGE FROM A SMALL INSTITUTION

By MARION L. CRIST

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THE individual disposal of sewage from a small institution like a hospital, school, or hotel, always offers considerable difficulty where conditions demand rather complete purification. The problem does not usually justify constant attendance at a treatment plant, and yet the hourly quantity and quality of the sewage flow vary so greatly that it is difficult to make a plant secure results without considerable attention. The prime requisites of a plant of this sort are, that it be simple, as nearly automatic and fool-proof as possible, in order to reduce attendance; and that it produce results.

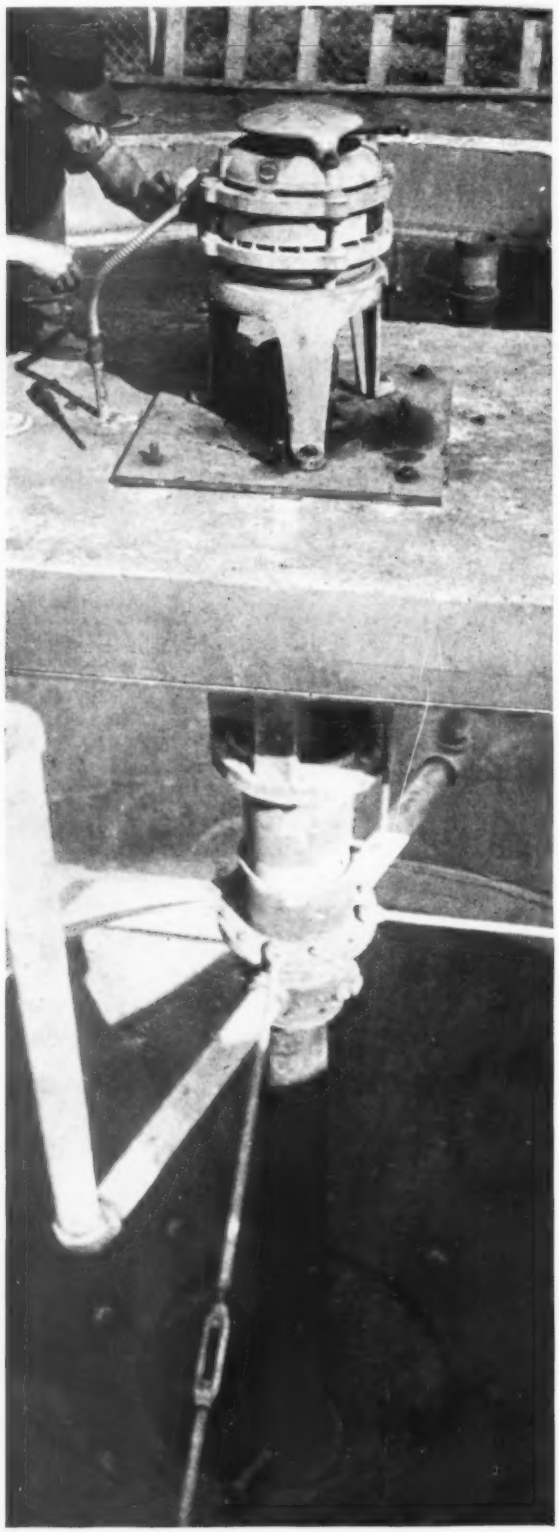
Installation for Hospital of 350 Population.—A plant has recently been installed at the Santa Barbara County Hospital and Farm which meets these requirements remarkably well for the particular set of conditions surrounding it. The hospital with a population of 350 is just north of Santa Barbara on the California Coast Highway. Being in a prosperous popular area, sewage disposal must be accomplished without odor or other nuisance. Further, since there is no diluting water available, a dependably stable effluent is essential to success.

The present average sewage flow from the hospital is 16,000 gal. per day. The maximum flow is at the rate of 120,000 gal. per day, and the minimum rate is 720 gal. per day. Adjacent to the hospital and a part of the farm, is a dairy. It was originally the intention of the engineers to treat the floor washings from this dairy in the sewage treatment plant. These washings amount to 7,000 gal. per day and come to the plant in two separate 4-hour periods. The plant was accordingly designed to treat a combined average flow of 50,000 gal. per day.

General Outline of Treatment.—Treatment consists of a preliminary sedimentation tank in the form of a small Imhoff tank with a sedimentation retention period of 40 minutes at average design flow. The sludge compartment of this Imhoff tank is very limited—130 cu. ft. Connected to this small sludge compartment is 4-in.

Sewage Disposal Plant at Santa Barbara County Hospital. Plant in Foreground and Hospital in Background

centrifugal pump which starts automatically each two hours and pumps the accumulated sludge from the Imhoff tank up to the old septic tank which has been slightly remodeled and now serves as a separate sludge digestion tank. The 4-in. pump is started by an adjustable time-switch which makes possible a pumping period of from zero minutes to 72 minutes in each two hours. It is, therefore, possible to adjust the pumping period of this pump so as to keep the Imhoff tank relatively free from accumulated sludge and still not pump an unnecessarily large amount of water through the digestion tank. Overflow liquor from the digestor is returned to the inlet of the Imhoff tank and passes on through the plant.



Aerator, Showing Arrangement in Tanks

The motor sits on cross-walk above water. Just below the walk the open intake ports appear and immediately below them the screw pump housing. (Small grease line enters housing.) Below the pump and the large casting with its anchors to the sides of the tank is the constricted throat with two air pipes coming out horizontally and rising to the surface. Lower still is the discharge going to the bottom of the tank. A metal deflector for forcing the air well out into the tank appears in the bottom.

Return sludge can be added to the settled effluent from the Imhoff tank and the mixed liquor then flows to a circular aeration tank with a flat-sided cone-shaped bottom. The aeration period so provided is six hours at average design flow with 20 per cent return sludge. Aeration is accomplished with a Watsco (Hardinge) aerator composed of a screw pump in the center of the basin with suction just below the surface and discharge at the bottom of the tank. Just below the pump in the discharge line is a constricted throat which reduces the pressure to less than atmospheric. From this point of negative pressure, air pipes are carried to the surface of the tank and air is allowed to inject itself into the pump discharge through small air orifices. The injected air is subsequently carried to the bottom and then rises through the mixed liquor contents of the tank.

The screw pump in this case is rated at 1700 gal. per minute and is driven by a 5-hp. electric motor. It is possible in this unit to inject air at rates up to 40 cu. ft. of free air per minute by regulating a valve on the air line, the maximum rate being equivalent to 1.14 cu. ft. of air per gallon of sewage at design flow.

After aeration the mixed liquor flows to a final settling tank of the Dortmund type. Liquor is introduced at the center 7 ft. below the surface and is withdrawn over a peripheral skimming weir. The average design detention period is two hours. The bottom of this tank is a steep-sided cone. Settled sludge is withdrawn from the bottom of the cone by a 1½-in. centrifugal pump driven by a variable speed rheostat controlled motor. This small sludge pump returns sludge to the effluent of the Imhoff tank, wastes sludge into the Imhoff tank sludge compartment, settling compartment, or any combination of these that may be desired.

The effluent from the plant flows into a dry ditch which passes under the Southern Pacific Railroad tracks and parallels the Coast Highway for several hundred feet. It finally percolates into the soil.

Very soon after the plant was placed in operation it became apparent that it would be impracticable to treat the dairy waste, because laborers at the dairy would not clean the floor before washing. The resulting large amount of stable manure quickly filled the separate sludge digestion tank, rendering its 3 cu. ft. capacity per design capita entirely inadequate. The waste did not appear to affect aeration except possibly favorably by adding to the weight of activated sludge. Ultimately the dairyman will be forced to clean the floor with shovels before washing, in order to reduce the load on the digester and so utilize the plant, but for the time being dairy waste is not entering the plant.

Operating Results.—The Imhoff tank with limited sludge capacity and bi-hourly removals of sludge to the separate digestion tank has proven entirely satisfactory. Through this plan the old septic tank is utilized with consequent saving in construction cost.

The Watsco aerator has now been in operation for 18 months without maintenance expense. The only

operation consists of daily inspection and oiling when necessary. During the past year the air valves have been left open which injects air at the rate of approximately 40 cu. ft. per minute, or on the basis of present flow at the rate of 4 cu. ft. per gallon. This air rises in a circle of approximately two-thirds the diameter of tank. The air and pump discharge combine to create positive stirring throughout the tank.

Dissolved oxygen tests taken in the aeration tank show from one-half to four parts per million of dissolved oxygen under all conditions. This is thought to be considerably higher than the corresponding test for other California activated sludge plants; a fact which is not at all surprising when it is remembered that the present detention period is slightly over ten hours and the present rate of air application is approximately 4 cu. ft. per gallon of sewage.

In spite of the high dissolved oxygen, it has so far proven impossible to build up a heavy dense activated sludge similar to that found in the conventional

Aeration Tank with Final Settling Tank in Background

activated sludge plant. The reason has not been definitely determined. It may rest in the quality of the sewage, which in common with the quantity varies so rapidly as to be indeterminate. The fact remains, however, that a certain sequence of events always occurs to prohibit the building up of dense sludge.

When all of the sediment from the final settling tank is returned to the aeration tank for a period of two or three weeks the percentage of sludge by volume after 30 minutes settling gradually increases in the aeration tank. The increase is probably directly in proportion to the increased suspended solid content. At any rate, at the end of two or three weeks a sample from the aeration tank settled for 30 minutes shows 100 per cent sludge content although the suspended solid content of the mixed liquor is probably not greater than 800 to 1000 p.p.m. During this whole period the sludge is almost white in appearance and occurs in large spongy flakes that are just barely heavier than water. Continued aeration at this stage either with or without sewage flow through the plant, makes very little change in the appearance of the sludge, but tends to decrease the specific gravity and cause the whole mass to float. If the sewage flow is allowed to continue through the plant during this period of continued aeration, sludge rises in the final tank and ultimately accumulates there in the form of a mat completely covering the surface.

During all of this time ample dissolved oxygen is available in the aeration tank to expedite the formation of dense activated sludge, although it usually does not exceed 3 p.p.m. The mat on the final tank does not become offensive and does not seem to affect the stability of the effluent.

The formation of this mat may be avoided by wasting sludge. Instead of returning most of the sludge from the final tank to the aeration tank and wasting only a small percentage, as is the usual procedure, fully half of the return sludge is wasted continuously. This practice has the effect of keeping the solid content of the aeration tank very low and of constantly exchanging the old solids for new arrivals from the sewage.

Just how important the long detention period and the large amount of air are in the success of this plan of operation has not been demonstrated. It is to be expected, however, that they are vital and it would, therefore, follow that the capacity of the plant so operated is much less than the corresponding capacity for other operation. However, this is a hypothesis as yet unproven. It may also develop, assuming that the present organic solids are being "burned up" as rapidly as they come to the plant, that with increased sewage flow and a corresponding increase in suspended solids, a dense truly activated sludge may become practicable.

Analyses of Sewage and Effluent.—Analyses of the raw sewage and final effluent as made by Mr. E. A. Reinke, Research Engineer for the California State Board of Health, follow: (These particular analyses were made in March, 1931. They are the average of two composite samples.)

	Raw	Settled	Final
Free NH_3	17	11.5	2.5
Org N	8.5	8	1.5
Nitrites	0.015	0.001	1.4
Nitrates	0.1	0.1	3.4
Oxy. Con.	190	144	40
B O D	367	262	4.5
D O	....	....	1.7
Suspended Solids	188	92	50
Vol.	165	86	34
Fixed	23	6	16

The operation of the plant is combined with other duties around the hospital. Verne Dawe, engineer at the hospital, spends such time as is necessary to inspect and oil the motors and keep the plant running. Power consumption approximates 5 hp. continuously, which at existing rates amounts to about $25 per month. In any event, the operation expense of a plant as small as this one is more or less negligible. The construction cost of the plant was $9,970.

All complaints of odor or other nuisance existing before this plant was constructed have disappeared, which in the final analysis is the ultimate measure of successful results.

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How to Make a Rain Gage

A "home-made" rain gage, constructed at the water works of Bellaire, O., is described by E. J. Lewis, Superintendent of Water Works, in the 10th annual report of the Ohio Conference on Water Purification. It was made as follows: A small copper tank 15.2 in. square and several inches deep is the tank in which rain is caught. One inch depth in this tank is equal to 231 cu. in. (1 gal.). A drain in this tank is connected by a tube to a bottle located in the laboratory. This bottle should have a capacity of about 2 gal. It is graduated by placing measured quantities of water in it so as to give readings in decimal fractions of a gallon which represent an equivalent depth in fractions of an inch of rain. Mr. Lewis states that such a gage can be made at practically no cost and it will give reasonably accurate and valuable rainfall records.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
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REAL PROGRESS BEING MADE IN TREATMENT OF WATER TO PREVENT CORROSION

THE August issue discussed reasons why progress in the treatment of water to prevent corrosion has been slow; the early uses of alkalies, the necessity for a protective film, and some of the literature on treatment to prevent corrosion were reviewed. The present article is a continuation of the review of the literature on treatments to prevent corrosion together with a discussion of the best means of treating water for maximum protection.

Lime Used Most Extensively for Treating Water to Reduce Corrosion.—Gould[28] describes the use of lime for preventing corrosion at Harrisburg, Pa., the lime being added to the filtered water. The normal dose was 8 to 10 lb. of hydrated lime per million gallons for each part per million of free CO_2 present. The pH was kept fairly uniform at about 8.5. Prior to the use of lime there was considerable drop in the dissolved oxygen of the water in passing through the distribution pipes. For the two months preceding the use of lime the drop in dissolved oxygen was about 4.4 parts per million. Immediately following the use of lime the reduction in dissolved oxygen drop was quite marked, then it gradually reduced to where there was a loss of only about 0.2 ppm. within a year. This indicated that practically all corrosion had been stopped.

Wilkison[29] states that three-fourths g.p.g. of lime, 1.0 to 1.5 g.p.g. powdered chalk, and 0.55 to 1.0 g.p.g. of silicate of soda were used in treating the Birmingham, England, water. This dose keeps the water very close to a pH of 8.3 at all times and gives satisfactory results as respects corrosion.

Day[30] treated the new gravity supply at Staunton, Va., with lime to prevent corrosion. About one year after putting the new supply in service, complaints of red water were received. Fifty pounds of lime per million gallons were applied to the water. This increased the pH from 6.6-7.2 to 7.8-8.4. The hot water systems still give some trouble. Watkins, in discussing the paper, stated that Norfolk water was treated with lime to increase the pH to 8.4 to 9.0. This has reduced the corrosion considerably. Wagner stated that sodium hydroxide had been substituted for soda ash at Danville as it was cheaper, only about one-third the amount being required. Engle stated that soda ash and sodium hydroxide had been employed at Big Bethel, and lime finally adopted.

Hatcher[31] gives a very good summary of the factors effecting corrosion of water pipe, and describes the several means of minimizing corrosion. He also gives some details concerning the deposition of a film of calcium carbonate on the pipe walls. Knox[32] describes the elimination of red water troubles at Asbury Park by aeration. The well water contains 27.5 ppm. of free CO_2, which is greatly reduced by aeration.

Caird[33] states that the lime treatment at Harrisburg, Pa., has been stopped after two years use on account of producing a large amount of deposit in the pipes. Soda ash is being used at times. In a paper presented at the Pittsburgh meeting of the American Water Works Association, May, 1931, Caird stated that about one year after stopping the lime treatment red water complaints again started. Enough soda ash is now being used to produce a pH of 7.0. The writer is of the opinion that Harrisburg has made a mistake in making such a material reduction in the corrosion prevention treatment. The previous treatment described by Gould may have been more than was necessary, especially if it produced too thick an incrustation of calcium carbonate, but the treatment was more in line with what is necessary to reduce corrosion to a minimum than the treatment described by Caird.

Forest, Roberts and Roetheli[34] studied the effect of the addition of lime and soda ash to brackish water on the corrosion of iron and steel. They concluded that a relatively high concentration of calcium salts and carbon dioxide at a pH of 8.5 or greater will cause the precipitation of a calcium carbonate scale on iron or steel surfaces exposed to brackish water. The addition of a small quantity of calcium bicarbonate in distilled water accelerates corrosion, while larger quantities permit the formation of a protective film. The addition of lime to water high in bicarbonate, or soda ash to water high in calcium salts will decrease the corrosion. Waters containing appreciable quantities of magnesium salts require soda ash as well as lime treatment to increase the pH and supply carbonate ions before a calcium carbonate scale can be built up.

Chase[35] found by laboratory experiments that the Falmouth, Mass., water could be corrected for corrosiveness more efficiently with lime than with sodium carbonate or sodium silicate. About 83 lb. of lime per million gallons were required, and this increased the hardness about 10 ppm. Hoover[36] states that corrosion of water pipes can best be prevented by treatment with

lime to the point where calcium carbonate will form an impervious film. He also describes the method of determining the saturation equilibrium of calcium carbonate.

The de-acidification of the Frankforter water is accomplished by passing the water upward through a bed of marble.[37] The free CO_2 is reduced from 30 to 2.3 ppm., and the pH is increased from 5.8 to 7.0. The water is filtered before passing through the marble bed. Hill[38] found that the discoloration of the Perth, Western Australia, water was due to extremely light flocculent type of rust in the water caused from corrosion of the mains. Lime treatment and improved circulation in the pipes alleviated the trouble considerably.

Fitzgerald[39] states that the use of hydrated lime to reduce the CO_2 in the Norfolk water was started in

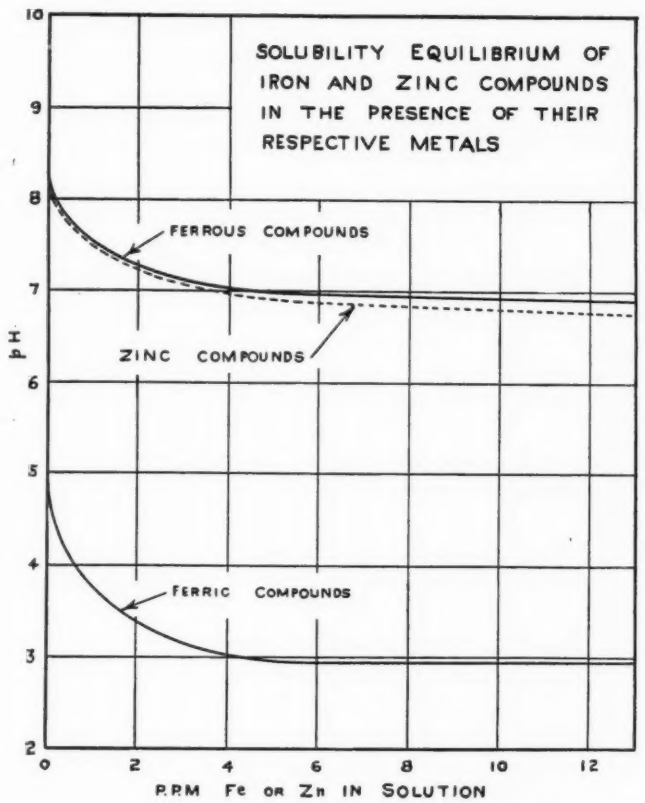

Fig. 1

1922. The carbon dioxide was not entirely neutralized, but about 5 ppm. was allowed to remain in the final effluent. This helped the red water troubles, but did not entirely eliminate such troubles. Experimental data indicated that to control the corrosion it would be necessary to have a phenolphthalein alkalinity of 6 to 8 ppm. Williams[40] used lime at West Palm Beach to prevent corrosion. The water is aerated to drive off CO_2, and lime is added to increase the pH to about 9.2. Corrosion troubles seem to have been stopped.

Grimley[41] describes how red water troubles were corrected in a small plant at Irondale, Ala., by aeration and by placing a block of "Purite" (block of sodium carbonate) on the collecting platform daily. The water before treatment has a pH below 5.2, alkalinity of 8, and free CO_2 of 46 ppm. Aeration increased the pH to about 6.5 and reduced the CO_2 to about 5 ppm. The "Purite" raised the pH to about 7.4. No further complaints have been received.

The writer, in 1930,[42] gave some of the factors involved in preventing corrosion of water pipes. Curves were given to show the solubility equilibrium of iron and zinc compounds in the presence of their respective metals. These curves are shown in Fig. 1. They show that practically no iron or zinc will exist in solution when the pH is above 8.0. At a pH of 7.0, several parts per million of either metal may exist in solution in some form in the absence of oxygen, and at a pH of 6.5, quite a large amount of iron or zinc may be found in solution in the absence of oxygen. The article explained how corroding iron took all the free CO_2 and much of the half-bound CO_2 from the water, leaving the water distinctly alkaline where there was no dissolved oxygen present. If the water contained dissolved oxygen the iron was precipitated as a hydrous oxide. Section of a 1-in. cement lined pipe, which had been in service for 50 years at Danvers, Mass., also was shown. The interior of the pipe was in fairly good condition, indicating that the lining was still giving very good protection.

Papers on Treatment of Water to Prevent Corrosion at the Pittsburgh Convention of the American Water Works Association.—Pirnie, in opening the discussion, gave a brief outline of the corrosion problem and treatments to prevent corrosion. He stated that, in general, corrosion could be greatly reduced by increasing the pH of the water, but that water with too high pH dissolved zinc. Dr. Hale read a paper prepared by Brush in which it was shown that some of the 6 in. and 8 in. pipes of New York City had only one-sixth their original carrying capacity. The Catskill water corroded much more rapidly than the Croton water. Experiments were being made with the application of an asphalt coating to the cement lined pipes to prevent the lime from being dissolved from the lining.

Fitzgerald stated that the use of hydrated lime after filtration to produce a pH of 8.4 has practically eliminated all corrosion complaints at Norfolk. The alkalinity of the water was increased from 22 to about 33, and the cost was about 40 ct. per million gallons. Hopkins stated that treatment of the Baltimore water with lime after filtration to increase the pH to 8.0 prevented aggressive CO_2. The cost was about 16 ct. per million gallons for 1930. Pipes which were installed 30 to 40 years ago are badly corroded, whereas those installed 10 years ago are practically free from corrosion.

McConnell stated that lime added to the filtered water at Charlotte, N. C., stopped red water complaints. The cost of the lime treatment is about 28 ct. per million gallons. Weston described the application of lime to the water from Wanaque Reservoir in New Jersey. The water had a pH of 6.3 and 12.0 ppm. CO_2. The addition of lime increased the pH to about 8.5 and greatly reduced the corrosiveness of the water.

Carrying Capacity of Pipes Greatly Reduced by Incrustation Resulting from Corrosion.—That the carrying capacity of iron pipes may be greatly reduced by tuberculation and incrustation as a result of corrosion is well known to most every one. Ledoux[43] states that he has known cases where 4 to 6 in. pipes were reduced 75 per cent in carrying capacity within 25 years, and many cases where the reduction was as much as 20 per cent in 10 years for cast iron pipes 12 in. in diameter and upward. Brush,[44] in discussing the treatment of the Catskill water to reduce corrosion, stated that two thousand feet of 48-inch pipe conveying the Catskill supply was removed after 9 years service and was found to be as badly tuberculated as pipe carrying the Croton water after 40 years service. In hot water lines where the temperature was generally above 160° F. the pipes clog in a very few years,

sometimes in a year or two. The cold water lines last, on an average, over 10 years.

A. T. Clark, in a paper presented at the Pittsburgh Convention of the American Water Works Association, showed illustrations of pipes containing various amounts of incrustation and tuberculation as a result of corrosion. A 16-in. pipe had an opening of only 10 in., an 18-in. pipe had a coefficient of only 63.5, and a 16-in. pipe with tubercles covering about 1/30 of the inside surface had a coefficient of 80.0. This is about equal to the carrying capacity of a new 12-in. main. The coefficient of friction in new pipes of this size should be above 150.

Biggs[4] reviewed the practice of 42 water works owned and operated by the American Water Works & Electric Co., and says that, "Possibly the reduction in carrying capacity by the formation of tubercles or incrustation of the interior surface of cast-iron pipe mains is the principal cause of worry and expense on the part of water-works managers." With decreasing carrying capacity resulting from corrosion it becomes necessary either to remove the tubercles or to install additional pipe, even though the capacity of the pipes would be adequate if they had not been reduced by corrosion. Tuberculation can be greatly reduced by entirely neutralizing or removing the CO_2. This according to Biggs is of particular importance after the mains are cleaned.

Haydock[4] describes how cleaning the tubercles or incrustation from several pipe lines increased the flow. One line carried only about one-half its theoretical capacity, and another about two-thirds. Cleaning a pipe line 3 miles long increased the capacity to the extent that a pumping station could be abandoned, and cleaning another line 5 miles long also enabled the abandonment of a pumping station. The friction loss through a 12-in. line 4 miles long 20 years old was nearly three times that of a new line. The capacity was increased by approximately 35 per cent and the delivered pressure by 20 lb. The gravity delivery of a 16-in. pipe 10.5 miles long was increased 60 per cent by cleaning. Cleaning a 13 mile section of a 12-in. pipe line 22 miles long, which had been in service about 16 years, increased the capacity approximately 35 per cent, and cleaning another section of the line 6 miles in length increased the carrying capacity to 46 per cent.

Increased Pumping Pressure or Larger Mains Very Expensive.—In some instances it is possible to deliver the desired amount of water through distribution systems that have become partially clogged by increasing the pumping pressure as the friction losses increase, or to install booster pumping stations on the distribution system in certain sections where the pressure is low. Haydock[4] refers to the delivered pressure being increased 20 lb. by cleaning the pipes in one instance. Assume that it was desired to maintain this 20 lb. increased pressure, evidently it was quite expensive to do it at the pumping station. A fair average of the cost of lifting one million gallons of water 1 ft. in height is probably about 5 ct. Twenty pounds is equivalent to about 46 ft. in head. In this case it would cost about $2.30 per million gallons to maintain the increased pressure.

If corrosion is going to reduce the carrying capacity of the water mains in a certain city 50 per cent within 20 years, what is the best way of handling such a situation? Should mains be installed large enough to give the desired capacity with a 50 per cent reduction in carrying capacity? The cost of such an investment over what would be necessary if there was no corrosion very likely would be much more than the cost of making the water reasonably non-corrosive. Then at the end of the 20-year period there must be an increase in pumping pressure, or the installation of more or larger feeder mains. What is happening in many cities is that their safety against fire is being gradually lessened as corrosion clogs the mains. The Fire Underwriters Inspection Bureau are constantly watching the pressure of the water in the various cities and demanding more pressure or larger mains. It is almost impossible for such an organization to test out every section of every city, and very likely there are many sections of many cities where corrosion has greatly reduced the safety from fire.

With the exception of feeder mains, engineers usually design the water distribution system for fire protection. How many engineers allow for a 50 per cent reduction in the carrying capacity of the pipes within 20 years where the water is corrosive? How many make any distinction whatever in the design where the water is corrosive and where it is not corrosive? The writer is of the opinion that corrosion has not been given its proper consideration in the design of water systems. This is largely due to the lack of specific information in the past as to how much the carrying capacity will be reduced within a certain time. Brush, as previously mentioned, stated that tuberculation in the water mains handling the Catskill water was as much in 9 years as was the tuberculation in the mains handling the Croton water for 40 years. Certainly this is worthy of consideration, and it may be given consideration in the design of piping systems for the two supplies, but the writer has not seen figures to show what this means in the operating cost of the water system. It is believed when specific figures are available it will far overbalance the cost of treating the water to make it fairly non-corrosive, plus the cost due to harder water.

Treatment with an Alkali for Partial Protection.—The literature on the treatment of water to prevent corrosion indicates quite conclusively that the corrosiveness of water may be greatly reduced by proper treatment. It seems that some of the authors of articles on corrosion prevention do not fully realize the importance of a film for protection. So long as iron stains are prevented, some think that this is all the treatment that is necessary. As a matter of fact the carrying capacity of the pipes may be reduced just as rapidly as before, because most of the corroding iron is deposited near where the corrosion is taking place and forms large tubercles that are more effective in reducing the carrying capacity of the pipes than if the rust was deposited fairly uniform over the surface of the pipe. Treatment just to the point where red water complaints cease may not materially reduce the cost to the water department for cleaning pipes, constructing new mains, and increasing the pumping pressure.

Saville[17] discusses the chemistry of pipe corrosion, the factors that influence corrosion, and means of preventing corrosion. He states that iron pipes must be protected to prevent corrosion, and that there are two types of coatings that satisfactorily prevents corrosion. One type is applied coatings placed on the pipes by the manufacturers, such as lead, asphalt, cement, and zinc. The other type is produced by deposits from the water such as organic matter, calcium carbonate, rust, and silicates. Whipple,[18] in 1910, attributed the red water troubles at Springfield, Mass., to the use of unprotected

metal. The trouble was confined largely to the hot water lines in apartment houses where the pipes, boilers, and tanks were either not protected, or the protection was not very good. He advised the use of well galvanized pipes, or better still, the use of brass pipes, and stated that the addition of lime to the water would largely prevent hot water troubles though there were objections to its use.

If the pH of the Springfield water was below the curve shown in Figure 1 for the solubility equilibrium of zinc, then the cause may not have been due to inferior galvanizing but to the galvanizing being dissolved from the pipes quite rapidly. The writer has shown[9]

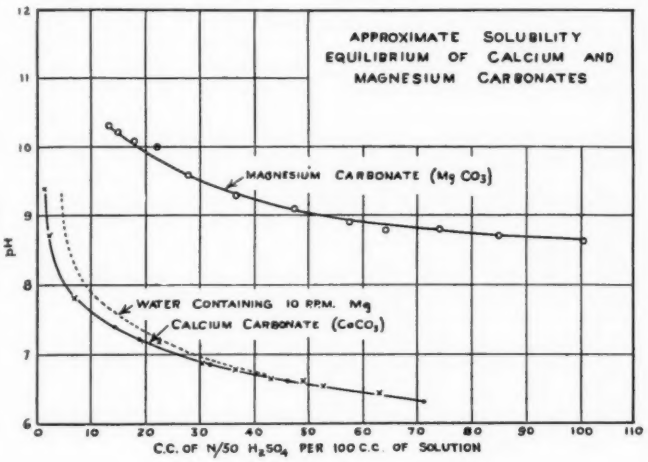
APPROXIMATE SOLUBILITY EQUILIBRIUM OF CALCIUM AND MAGNESIUM CARBONATES
MAGNESIUM CARBONATE ($MgCO_3$)
WATER CONTAINING 10 RPM. Mg CALCIUM CARBONATE ($CaCO_3$)
pH
C.C. OF N/50 H_2SO_4 PER 100 C.C. OF SOLUTION

Fig. 2

that it is not advisable to depend on zinc for pipe protection where the temperature is above about 160° F., for zinc will then corrode with the liberation of hydrogen gas in most any kind of water above this temperature. The treatment of water to give long life to galvanized pipe is not different from the treatment most suitable for protecting the larger mains. There is some evidence that water with a pH too high will hasten the corrosion of zinc, but if this high pH is produced by the addition of lime to the water, a protective coating of calcium carbonate will be formed long before all the zinc is dissolved.

Water Just Saturated with Calcium Carbonate Is the Most Desirable Equilibrium.—As a general rule, it might be said that water saturated with calcium carbonate is the most desirable equilibrium when everything is taken into consideration. This is not strictly true for very soft waters, for it is desirable to have the water slightly supersaturated part of the time so as to form a thin protective film. Where the calcium carbonate alkalinity of the water is below 30 parts per million the application of lime to produce a slight supersaturation of calcium carbonate should be done with considerable care, otherwise caustic water might be produced. After a thin coating has been formed on the pipes the water should be kept saturated with calcium carbonate practically all the time to keep the coating from being dissolved. It is admitted that the very soft waters are the most difficult to protect, for we are working with equilibriums difficult to maintain exactly on the saturation point. It may be almost impossible to do this with the force available in small plants and it may be necessary to sacrifice some protection to avoid occasional caustic taste in the water. There is no reason why large plants with skilled supervision should not be able to maintain a fairly constant equilibrium.

Where water has a calcium carbonate alkalinity in excess of about 30 it is easier to protect the pipes. If this water is placed in contact with an iron surface the iron going into solution will take up all the free CO_2 that is in the water and part of the half-bound CO_2. Table I shows how quickly the pH changes in water exposed to iron lathe turnings. After the pH reaches 8.1 no free CO_2 is present.

TABLE I—RAPID INCREASE IN pH CAUSED BY CORRODING IRON

Alkalinity	Time in Contact with the Iron Minutes	pH	Fe in Solution
39	0	7.2	
	1	7.3	
	2	7.4	
	3	7.7	
	5	8.2	
	10	9.2	
	15	9.4	
35	20	9.6	0.0tr.

About 75 grams of lathe turnings were placed in a one-liter flask and one liter of water with a pH of 7.2 and alkalinity of 39 added. Nearly all the alkalinity in this water was calcium carbonate and the water was soon increased in pH to where it was saturated with calcium carbonate. This was due to the CO_2 combining with the corroding iron.

At any point on the surface of an iron pipe where corrosion starts to take place due to the surface becoming exposed in some manner, there is a tendency for the iron going into solution to take up the free and part of the half-bound CO_2, producing a supersaturation of calcium carbonate in the immediate point where corrosion is taking place. This supersaturation helps to quickly form a coating over the exposed surface both

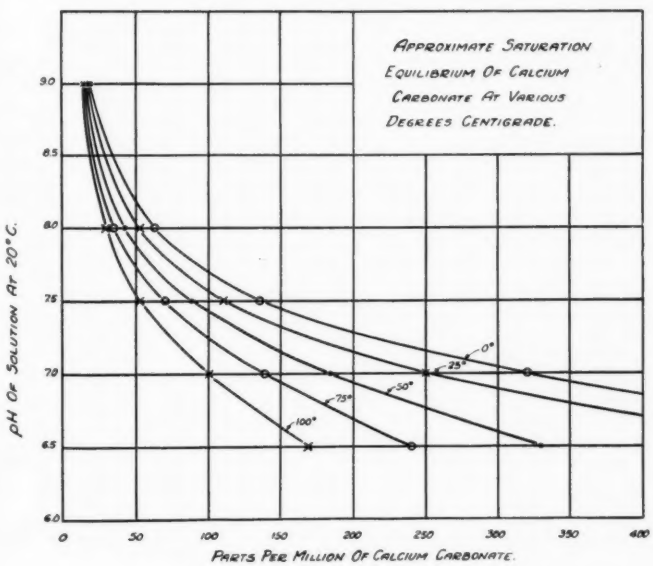
Approximate Saturation Equilibrium Of Calcium Carbonate At Various Degrees Centigrade.
pH Of Solution At 20° C.
Parts Per Million Of Calcium Carbonate.

Fig. 3

by precipitating the iron compounds and also some calcium carbonate, especially when the water has a fairly high alkalinity. If the water in the mains is saturated with calcium carbonate, then the precipitated calcium carbonate will not be dissolved out of the precipitate. It will remain where it is precipitated to offer protection against further corrosion.

How to Determine If the Water Is Saturated with Calcium Carbonate.—The saturation equilibrium of calcium carbonate for various pH values has been determined fairly accurately where there are no other compounds to interfere. The writer has published a curve

in several articles showing the approximate equilibrium as determined from actual tests. The equilibrium is affected by certain compounds that may be in the water, and for natural waters the best procedure is to determine the equilibrium by tests for the particular water. This is done by treating the water in a manner in which it is desirable to treat in a plant to the point where it is thought the treatment will make the water saturated with calcium carbonate. If lime is to be used in the plant, then the water should be treated with lime; and if soda ash is to be used, then this should be used in the test. Usually the water is already being treated with an alkali and it is only necessary to collect a sample of the water after treatment.

Place the water in contact with powdered calcium carbonate in a closed flask and agitate until equilibrium has been established. If a one-liter flask is used, place at least 200 grams of powdered calcium carbonate in the flask and wash several times with water the same as is to be tested. Fill the flask nearly full of the water to be tested, first determining its pH and alkalinity. If agitated constantly, the equilibrium should be established within 24 hours. When agitated frequently by hand, it should be kept up for about 3 days. The flask should be stoppered tightly so that CO_2 from the air will not affect the results. If either the pH or alkalinity changes, equilibrium has not been established. An increase in alkalinity indicates the water is not saturated and a decrease indicates that it has been supersaturated.

Most natural waters contain magnesium carbonate as well as calcium, and the presence of a considerable amount of magnesium may materially alter the equilibrium curve. This is shown by the curves in Fig. 2. The presence of sodium carbonate also alters the curve, but its effect has not as yet been determined. When sodium carbonate is present the only way the saturation equilibrium of the water in regards to calcium carbonate can be determined is by actual trial.

Temperature also has an effect upon the saturation equilibrium of calcium carbonate. The curves shown in Fig. 2 were determined at room temperature, that is, about 20 to 22° C. The other curves are based on actual tests, but not enough were run to state that the curves are absolutely correct. They should be regarded as somewhere near the true lines.

Corrosion prevention by treatment of the water has been demonstrated to be practical and economical. This being true, then it seems that all corrosive waters should be treated. The writer hopes that those in charge of water works will give the matter more consideration than many have in the past.

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Central States Section A.W.W.A. Convention

The tentative program for the annual convention of the Central States Section of the American Water Works Association, which will be held Oct. 8 and 9 at the Starretts' Netherland Plaza Hotel, Cincinnati, O., follows:

Thursday Morning, Oct. 8

9:00 A. M.—Registration at Hotel Netherland Plaza.
10:00 A. M.—Convention called to order.
10:05 A. M.—Address of Welcome by Mayor Russell Wilson.
10:15 A. M.-12:00 A. M.—Papers and business.

Thursday Afternoon, Oct. 8

2:00 P. M.-4:30 P. M.—Papers and discussions.
4:30 P. M.—Election of Officers and selection of place of 1932 Meeting.

Thursday Evening, Oct. 8

7:00 P. M.—Banquet at Hotel Netherland Plaza.
(125 to 150 attending.)

Friday Morning, Oct. 9

9:00 A. M.-11:00 A. M.—Papers and discussions.
12:00 Noon—Steamer trip and buffet or box lunch.
Return about 5:00 P. M.

LADIES' PROGRAM

Thursday, Oct. 8

12:30 P. M.—Luncheon, Netherland Plaza.
(Possibly 30 attending.)
2:00 P. M.—Sightseeing trip.
Rockwood, Stirling Glass, Ivorydale.

Friday Morning, Oct. 9

Shopping tours as arranged.

RED WATER IN OHIO SUPPLIES.—Data collected by the State Department of Health from 221 Ohio municipalities, which use well water untreated, show that 100 of these municipalities have a water supply in which there is an objectionable iron content.

GREENSAND WATER SOFTENING ZEOLITES

By CHURCHILL HUNGERFORD

President, Inversand Company, Clayton, New Jersey

FOR many reasons, of which cheapness and durability are not the least, the use of greensand zeolites for water softening is advancing rapidly throughout the world.

The greensand water softening zeolites are often referred to as "natural zeolites" and a very prevalent idea exists that greensand in its natural condition, or merely washed and graded, is employed. If this were true, zeolite water softeners could be built for little more than the cost of water filters. As a matter of fact, greensand is little more than a foundation upon which a rather complex chemical treatment is erected.

The greensand deposits of America are extensive. White not confined to the coastal plain, the greatest and most available beds of greensand underlie the eastern portions of New Jersey, Delaware, Maryland, Virginia and North Carolina. The New Jersey deposit, from which most of the present supply is drawn, extends southeast from a line drawn from Atlantic Highlands to Salem and underlies the entire state southeastwardly of that line, probably extending far into the ocean. This deposit varies in thickness from 12 to 65 ft.

The local name given to greensand throughout the state of New Jersey is "marl" and this term is often used in technical reports. The United States Geological Survey Reports almost invariably refer to it as marl.

Greensand is a mixture of glauconite grains, glauconitic clay, clay, sand, lime and pebbles. The generally accepted theory of the origin of greensand is that it is the fossil imprint of foraminiferal shells. It is believed to have been deposited at the bottom of the ocean at a depth of approximately 600 ft. and its age is placed at from 15,000 to 25,000 years.

The Hornerstown and Navesink marls employed in zeolite production when mined have the appearance of black or greenish-black mud. These deposits range from 12 to 16 ft. in thickness.

Upon drying, the greensand develops the characteristic color which gives it its name. It is generally a dull olive green, but the grains of glauconite, after separation from the surrounding mud and clay, are always green.

Following are two chemical analyses of greensand taken from the deposit of the Inversand Co. at Sewell, N. J. One is the raw marl as dug, containing the enveloping clay, etc., and the other is of the same product after washing in several waters to remove the clay but not the fines.

	Raw Marl Per Cent	Washed Marl Per Cent
SiO_2	51.83	50.38
Fe_2O_3	17.15	18.69
FeO	2.92	2.61
Al_2O_3	6.23	7.83
CaO	0.52	0.37
MgO	3.66	3.54
K_2O	6.60	7.85
Na_2O	0.76	0.30
CO_2	0.36	0.10
P_2O_5	0.31	0.28
H_2O	9.98	8.70
	100.33	100.65

The loss of the raw air dried marl upon washing (clay, etc.) is roughly 15 per cent. Upon screening to an effective size of 0.36 mm. with a uniformity coefficient of 1.54 the loss of clay and fines together is approximately 40 per cent leaving 60 per cent or thereabouts of the greensand available for the manufacture of zeolite.

This product may be classified as pure glauconite. In appearance it is olive-black sand when dry and black when wet. When air dried it weighs, including

Greensand Pit of the Inversand Co., Clayton, N. J.

Stripped Greensand Bed and Zeolite Plant of the Inversand Co., Clayton, N. J.

fines, 96 lb. per cubic foot. The grains are comparatively soft and when wet can be ground into a green mud between the thumb and forefinger.

This refined glauconite has base exchange properties. After regeneration with salt, hard water can be passed through it and the lime and magnesia of the water completely removed, but the forces of base-exchange acting upon the glauconite when in the sodium state disrupt the grains and render the softened water extremely turbid with the light pea-green mud characteristic of powdered greensand. This turbidity continues but with gradual diminution through the entire softening run. When the zeolite is brought to the calcium condition the water comes through clear but unsoftened.

This disintegrating action is extremely active and becomes more pronounced with softer waters. In softening water of 2 degrees as high as 33 1/3 per cent of some greensands may be broken up and carried away in the form of light green colloid clay in one regeneration. In the succeeding regeneration about the same proportion is carried away and this proportion seems to persist until the entire body of greensand is dissipated. If on the other hand a 17 grain water is softened the loss from powdering is about 15 per cent on the first regeneration. Because of this powdering which is most pronounced just following regeneration with brine it is difficult to estimate the exchange value of greensand.

By taking a definite weight of greensand, regenerating it with salt and running to the point where the hardness in the effluent makes its first appearance, then weighing the greensand after this test and adding the two weights together and dividing by two we have the average amount of greensand that has been employed to soften the water. For example:

If 800 grams of washed greensand is regenerated and run just to the point where the first indication of hardness appears and the greensand, after being dried, weighs 680 grams we can consider the amount of greensand functioning during the test was 740 grams.

By following this plan we find that washed untreated greensand shows an exchange value of 3100 grains to the cubic foot. The total exchange value, if the test is carried through to a point where no more hardness will be removed, is in the neighborhood of 5000 grains.

Those who have claimed that greensand as such can be used in water softening have undoubtedly tested with extraordinarily hard water, but even then the softened water is far from clear because of the greensand disintegration. Untreated greensand is quite unsuitable as a water softening zeolite. It has, however, a valuable property that can be employed in that it is a mineral containing the necessary elements for the production of a stable base exchange body.

Two courses of treatment of raw greensand are open. One is the stabilization of the glauconite without changing its component parts and the other is the employment of the valuable elements contained within the glauconite for the manufacture of a water softening zeolite. The first greensand zeolite actively employed in water softening consisted of glauconite stabilized by heat. This process was covered by patents as was also another process where hot oxidizing and reducing gases were passed through a bed of glauconite. Stabilization by heat has probably been discontinued. It may be employed in conjunction with certain chemicals but the mere baking and oxidizing of the glauconite seems to be so inferior to other and more reliable methods that it is not necessary to consider the stabilized product further.

In the chemical treatment of glauconite cognizance is taken of the fact that the raw glauconite possesses certain deficiencies that must be built up. To increase the softening capacity as great a porosity of the product as possible must be obtained. Certain undesirable elements, such as sulphides, humua, etc., must be removed by leaching or otherwise. It is not necessary to destroy the structure of the greensand grains to obtain these ends, although the completed product is quite a different article from the untreated glauconite, even though it has much the same appearance. After treatment and screening it can be classified as a greensand zeolite, weighs from 89 to 93 lb. per cubic foot, is from four to fourteen times as hard as the original glauconite and, depending upon its size and uniformity of grain, one cubic foot will completely soften from 220 to 410 gal. of water having a hardness of 10 grains to the gallon, measured as $CaCO_3$.

In explanation of the great variation in exchange value let it be understood that greensand zeolite is practically non-porous and that most of the softening action takes place on the surface of the grains. Therefore since small grain zeolite has a greater surface area per unit volume it follows that the exchange value will be correspondingly greater than is obtained with coarser material.

It will be observed that the greensand zeolite is made up of grains possessing a uniform degree of hardness. This hardness is regarded as an indicator of the in-

Zeolite Plant of Inversand Co., Clayton, N. J.

solubility or tendency to resist the disintegration previously referred to as the result of base exchange forces acting on the material.

An accurate device for determining the hardness of greensand zeolite was developed. The erosion that takes place in this device is used as the index of softness. By this test washed and graded greensand shows an erosion of 1000 units whereas the finished zeolite shows values from 72 to 280 units only. Reduced to practical operating sizes, say .32 to .36 mm. effective size, the exchange value of the greensand zeolite ranges from 2700 to 3100 grains of hardness, computed as $CaCO_3$, to the cubic foot of zeolite. These figures give the amount of hardness that can be removed without any hardness appearing in the softened water. They do not represent the total exchange value which is from 40 to 70 per cent greater but is not generally utilized in practice, it being customary to regenerate the zeolites when the first indication of hardness appears in the softened water.

Compared with synthetic zeolites which possess exchange values from 6000 to 12,000 grains per cubic foot it would seem that the greensand zeolites would have little application. They have, however, other characteristics which more than compensate for the low exchange value. Iron bearing waters for example have little effect upon them, but are decidedly destructive to the synthetic zeolites. The greensand zeolites give a much better account of themselves with acid waters and can usually be relied upon to operate continuously and successfully at a pH of 6.4 and upward. Under average operating conditions there is practically no wear upon the greensand and no lowering of its exchange capacity with extended use. By reason of its high gravity an up-flow water rate of 8 gal. per square foot per minute during softening can be maintained without the necessity of employing screens to prevent loss of zeolite. The greensand zeolites seem to be especially suitable for the up-flow system of softening.

The low exchange capacity may be compensated for in up-flow softeners if need be by increasing the depth of the bed. The greensand zeolites are cheaper than the synthetic ones but are bulkier. Thus, a softening unit of any capacity can be built with greensand or with any of the synthetic zeolites for about the same cost. Either will require equal amounts of salt for equal performance.

At one time a decision of the Appellate Court, sustaining a patent upon the downward passage of water through a zeolite bed for softening, thrust an unwilling acceptance of the up-flow principal of softening upon some manufacturers of zeolite softeners. These manufacturers proceeded to develop the up-flow softener, with the result that greatly increased rates of softening were obtained, 8 gal. per square foot per minute being a practicable speed. Increased depths of bed, 10 ft. or more being practicable, were found to be advantageous, and a material reduction of pressure losses through the softener resulted.

The greensand zeolites have the faculty of almost instant regeneration. The brine cannot be put through the softener at a rate so fast that regeneration is not complete.

By virtue of the high gravity of greensand zeolites, troublesome and damaging top-screens are not necessary in up-flow softeners. The hardness and the rounded contour of the grains minimizes loss from wear.

The greensand zeolites should do much to advance water softening by municipalities. Their low cost, their durability, their almost instantaneous regeneration, their economy of salt and their applicability to open tank construction, whether up or down-flow, make practicable many municipal installations that have heretofore been considered non practical. Failure of greensand zeolite manufacturers to screen the zeolite to filter sand specifications has been a retarding factor but appreciation of the many advantages gained from the use of a large uniform grain has caused at least one manufacturer to meet this requirement. Others will doubtless follow suit and the problem of properly preparing and grading having been overcome, the many advantages of the greensand zeolite should give it as prominent a position in the field of municipal softening as it now enjoys in the industrial field.

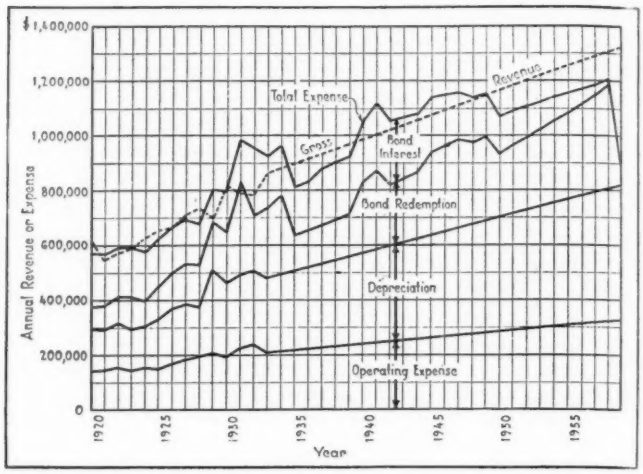

Fig. 1—Financial Survey of Program

FUTURE WATER WORKS DEVELOPMENT AND WATER RATES

By W. A. KUNIGK

Superintendent, Water Division, Department of Public Utilities, Tacoma, Wash.

IN Tacoma the Water Department is operated as a separate branch of the Municipal Utility Department and does not receive aid of any kind from the general fund or other city departments, except for services rendered. In fact, such service as hydrant service, sewer flushing and street sprinkling, is furnished to the city at a charge of $78,000 per annum, while the department estimates that the actual cost of such service is in the neighborhood of $135,000. The water department also pays a rental for office space occupied in the city hall, as well as for the prorated cost of the services of the city corporation counsel, city treasurer, city controller and city clerk. Besides these expenditures the water department has for many years paid a 5 per cent gross revenue tax into the general fund. In the current year this gross revenue tax will be 7.5 per cent or approximately $60,000. After providing for these items of expense it is important that a sufficient balance remains from the gross revenues to cover all other obligations. Aside from the expense items already enumerated, it is the aim of the Tacoma Water Department to have the gross revenue produce a sufficient income to cover operation and maintenance expense, interest and redemption of outstanding bond obligations and depreciation of plant. The only funds available from the department for plant replacements, betterments and extensions are, therefore, the moneys from the depreciation fund, surplus and moneys from utility bonds authorized by the city council. In other words, the water department must stand on its own bottom.

On account of the industrial growth the city of Tacoma has experienced in the last few years, with the consequent demand for large quantities of additional water, a number of problems have come up for study and consideration in connection with the water rates that no doubt are more or less typical of the problems other Pacific Northwest cities have had to meet. A brief review of some of these problems will provide a better perspective of the water department's finances and their relationship in reference to the water rate problem.

The Water Supply of Tacoma.—The principal source of Tacoma's water supply is derived from the Green River through a single gravity pipe line, 43 miles long with a capacity of 42,000,000 gal. per day when constructed. This line was completed and placed in service during 1913. Forty-one miles of the total length were built of continuous wood stave pipe and in 1924 it became necessary to start the reconstruction of the wooden portion of this pipe line. A program was worked out whereby every year from 1½ to 3 miles of pipe were to be rebuilt according to the requirements of the physical condition of the pipe so that the whole pipe line will have been renewed by 1940. In view of the fact that the rate of depreciation is computed on a plant value of wood pipe on prewar prices, all of the funds derived from the depreciation allowance are used up in gravity pipe line reconstruction, and new capital must be added to replace with the more expensive steel and concrete now used. A large part of the program for plant extensions and betterments is, therefore, financed by the issuance of utility bonds.

Additional Water Supply Needed.—On account of the advent of several large pulp and chemical plants in the city, it also became necessary to start the development of an additional water supply. In bringing these new plants to the city the water department had agreed to furnish water to these industries on a basis of 2 ct. per 100 cu. ft., or $26.67 per million gallons for consumptions from 1,000,000 to 3,000,000 gal. per day; for all consumptions over 3,000,000 gal. per day water was to be supplied on a basis of 1½ ct. per 100 cu. ft., or $20 per million gallons. Upon negotiations with a number of pulp plant engineers, it became evident that after consideration of other local conditions, such a low water rate as quoted, would act as an additional inducement to locate these plants in Tacoma.

Before the question of the development of this industrial water supply came up for a decision, careful estimates were made of all expenditures and possible gross revenues for a period of over 20 years in the future so that an anlysis could be made as to the soundness of the financial ability of the water department to carry out this program under existing water rates for ordinary domestic and industrial consumers and the special rate under consideration for the new large industries. Several gravity systems were investigated and estimates were prepared, but it became apparent very soon that it would be impossible to carry out the other financial obligations of the water department and at the same time embark on the construction of an additional gravity supply system, involving an expenditure of some $2,500,000 or $3,000,000 without a considerable raise in the present water rates. This, of course, was not contemplated.

Well Supply Selected.—A study of our water supply records indicated that with the additional load of from 12,000,000 to 13,000,000 gal. daily on account of the new industries, the deficiency in the supply line would, during the summer months of June, July and August,

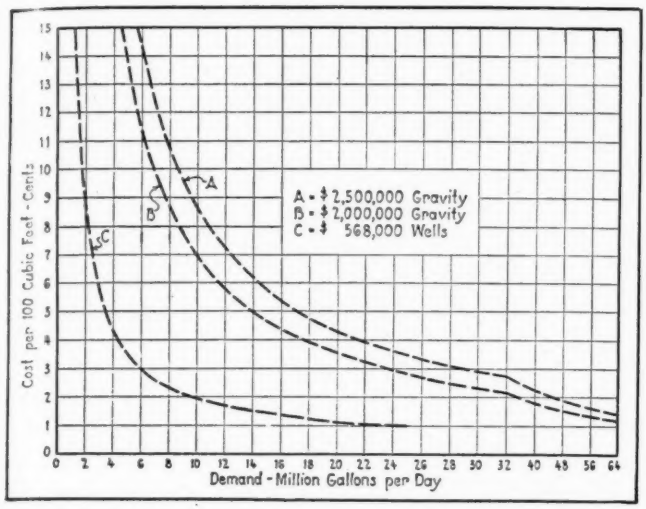

Fig. 2

be as much as 15,000,000 or 16,000,000 gal. daily. During the balance of the year there appeared to be ample capacity in the Green River Gravity System to take care of the city's demands for some years to come. From 11,000,000 to 12,000,000 gal. daily of the midsummer deficiency could be made up from an auxiliary well supply system which the water department has maintained in the South Tacoma district since 1908. A study of the general favorable geological conditions in and near South Tacoma for the development of a large water supply from wells at a low plant investment, in conjunction with the low power rate from municipally owned power plants, led to the decision to develop an additional water supply from wells, equal in capacity to that of the gravity supply system. When this plant is completed the city will have ample protection in case of a complete failure of the gravity supply line during any time of the hazardous reconstruction period. A well system supply of 25,000,000 gal. daily capacity has already been developed and the plan now being carried through promises to meet all expectations under the original estimates without upsetting the present rate schedule. The full effect of the benefits of this development on Tacoma's water rate will, of course, be more apparent in the future than at the present time.

The Development Program.—Some of the major expenditures, for plant reconstruction, betterments and extensions that are part of Tacoma's program will here be enumerated to furnish a better perspective and background indicating the necessity for a comprehensive study of plant requirements and finances for at least 20 years in the future:

1. Reconstruction of the Green River Gravity System between the period from 1923 to 1941. Estimated cost, $3,760,000. Capacity of system to be increased from 42,000,000 to 57,000,000 gal. daily.

2. Duplicate gravity pipe line of 12 miles in length to be built between 1936 and 1939 from a point near McMillin Reservoir to Tacoma. Estimated cost, $995,000.

3. The present air-lift well system of 12,000,000 gal. daily capacity to be replaced by a new well development of not less than 40,000,000 to 45,000,000 gal. daily capacity. Work began in 1930 and is to be completed during 1932. Estimated cost of well development and pumping equipment for individual wells, $200,000.

4. Trunk main progress, especially for industrial area, was begun in 1928 and is to be completed during 1932. Estimated cost, $602,000.

5. Booster pumping plant, capacity of from 25,000,000 to 30,000,000 gal. daily with inter-connections between low and high service systems will be completed during 1931 and 1932. Estimated cost, $120,650.

6. Major trunk mains in distribution system to be completed between 1929 and 1933. Estimated cost, $400,000.

A complete picture illustrating the financial survey of this program and other necessary expenditures and plant income is given in Fig. 1. This diagram shows a clear analysis of all proposed plant expenditures and estimated income during the entire redemption period of all proposed bond issues. Such a study of expenditures and income commends itself, especially in connection with proposed rate studies.

An analysis of possible economies from a well development as compared with the heavy carrying charges of a gravity pipe line development is shown in Figure 2. It also illustrates the fact that future well development can be made in successive steps of small units keeping in line with future growth without burdening the Water

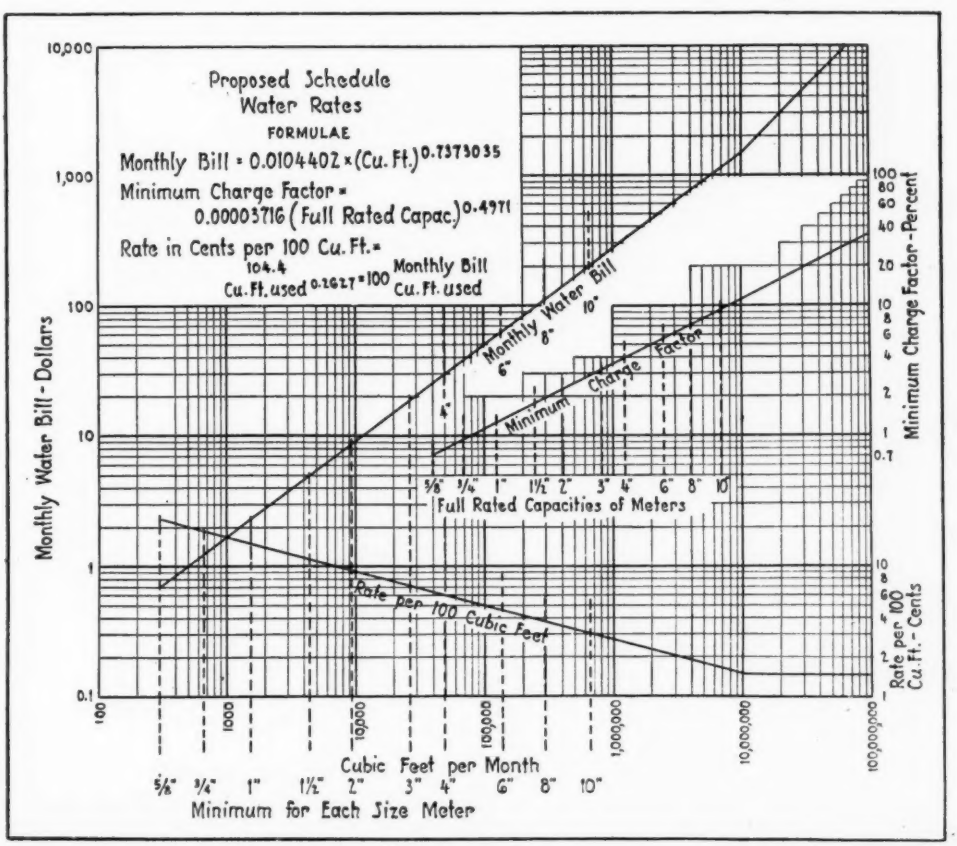
Proposed Schedule
Water Rates
FORMULAE
Monthly Bill = 0.0104402 x (Cu. Ft.)^0.7373035
Minimum Charge Factor =
0.00003716 (Full Rated Capac.)^0.4971
Rate in Cents per 100 Cu. Ft. =
104.4 / Cu. Ft. used^0.2627 + 100 Monthly Bill / Cu. Ft. used
Monthly Water Bill - Dollars
Minimum Charge Factor - Percent
Rate per 100 Cubic Feet
Full Rated Capacities of Meters
Cubic Feet per Month
Minimum for Each Size Meter

Fig. 3

Department with large amounts of capital invested for many years in idle plant capacity. The most surprising result brought out by the well development is that a complete auxiliary well system can be installed under conditions existing in Tacoma, at a cost less than one-sixth of the present gravity system. The effect of this program on future water rates is self-evident.

Water Rates.—Figure 3 illustrates graphically a study that the Tacoma Water Department has made of a proposed water rate for the city of Tacoma to supersede the present rate which in some respects is not entirely satisfactory. The present meter rate is made up of a ready-to-serve charge and a charge for water furnished as follows:

Size of Meter	Service Charge per Month
⅝ in.	$ 0.50
¾ in	0.75
1 in.	1.50
1½ in.	3.00
2 in.	5.00
3 in.	10.00
4 in.	15.00
6 in.	30.00
8 in.	50.00
10 in.	90.00
12 in.	130.00

The charge for water consumed is 10 ct. per 100 cu. ft. for the first 5,000 cu. ft.; 6 ct. per 100 cu. ft. for the next 25,000 cu. ft.; and 4 ct. per 100 cu. ft. for all consumptions over 30,000 cu. ft.

The ready-to-serve charge covers a portion of the cost of furnishing water based on the capacity of the meter and the cost of providing reserve capacity at all times, regardless of the amount of the consumption. The service charge produces approximately one-third of the meter revenue in Tacoma and helps, therefore, to reduce the unit rate on all water consumed. In reference to the application of the service charge, we find that the consumers invariably look on this charge as an additional charge over and above the cost of water furnished. It is for this reason the Tacoma Water Department proposes to adopt a minimum charge in lieu thereof, for which a certain quantity of water will be furnished. The rate schedule worked out in Fig. 3 is what might be termed the logarithmic rate scale. The equations involved establishing the slide as contemplated under the scale are given in Fig. 3.

The Rate Scale.—The novel feature about this rate scale is the minimum charge based on a load or charge factor which is used in connection with power rates, but which the writer has never seen applied to water rates. For instance, it was assumed that a large consumer requiring approximately 6,000,000 to 8,000,000 gal. of water per day should guarantee to the department an income of not less than $1,500 per month, or $18,000 per annum in order to protect the necessary plant investment as far as possible. For this minimum charge the consumer would be entitled to 75,000,000 gal. per month, which is at the rate of $20 per million gallons, or 1½ ct. per 100 cu. ft. This is the lowest rate now quoted by the city of Tacoma. On the other end of the scale it was assumed that a minimum revenue of 70 ct. per month was necessary from a ¾-in. service with ⅝-in. meter and that 300 cu. ft. of water would be furnished for this minimum charge. The slide between these two extremes in the rate represents a straight line on the logarithmic scale of Fig. 3.

The minimum charge factors for different sizes of meters represent the coefficients to be applied to the maximum capacities of the respective sizes of meters, assuming approximately a 5 lb. pressure drop in the meter. The minimum monthly charge for each size of meter is then established on the basis of the regular scale rate applied to this minimum quantity of water so determined. The assumption for the minimum charge requirements for the smaller meters are based somewhat on Allen Hazen's Table of Load Factors in his book on "Meter Rates" and for the large meters these charges were based on an arbitrary minimum revenue which it was felt was necessary to protect the investment of the Water Department.

From a theoretical standpoint, this scale is simple enough, but its practical application is not quite so simple as it looks. The diagram would either have to be plotted on a large scale logarithmic paper or bills would have to be computed with a log-log slide rule. Either method would be difficult to explain to the consumer.

The water department has already computed a table from which all bills for consumptions from 0 to 10,000,000 cu. ft. can be read directly. This, the writer feels, is the simplest method for making this rate scale practical in its application.

The writer herewith wishes to acknowledge his indebtedness to Lothrop Crosby, Hydraulic Engineer in the water department, and B. P. Thomas, Assistant Superintendent in the same department, for their assistance in the preparation of estimates and the rate diagram, which are part of this paper.

Acknowledgment.—The foregoing is an abstract of a paper presented at the meeting of Pacific Northwest Section of the American Water Works Association.

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Large Siphons at New Orleans

Lennox Pumping Station, now nearing completion in the Algiers section of New Orleans, has two siphons, each of which measures 14 ft. in diameter.

The huge siphons have a capacity of 100 cubic feet per second each and are electrically welded throughout. There are two 100-in. wood screw pumps with a capacity of 400 cu. ft. per second. A constant duty pump with a capacity of 150 cu. ft. per second is also installed. The station, in addition, has two 10-ft. siphons installed.

The new station is located in what a year ago was a marsh and was designed to take all the drainage water from the 11,500 acres which comprise that part of the parish of Orleans that lies on the west bank of the Mississippi river.

One feature of the new pumping station is that the drainage water from the highlands will be kept entirely separate from the drainage from the flooding lowlands, according to A. Baldwin Wood, chief mechanical engineer of the Sewerage and Water Board of New Orleans. It is this separation of the highland water from the lowland flow that makes it necessary to have the unusual number of walls and siphons.

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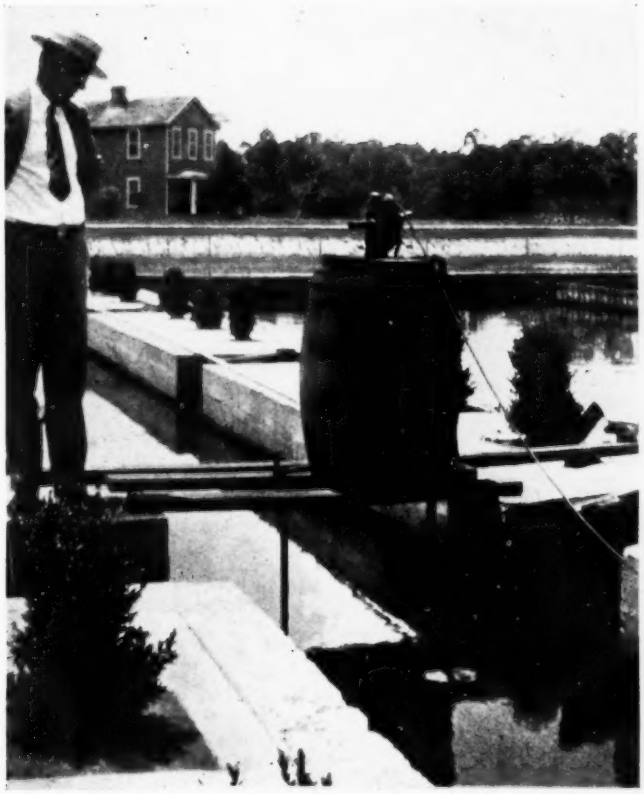
STATE AND MUNICIPAL FINANCING.—Financing by states and municipalities for the first eight months of this year, according to *The Daily Bond Buyer*, amounted to $1,016,520,945, the largest figure recorded for the first eight months of any year since 1924. During the first eight months of that year total bond sales amounted to $1,064,208,220, the nearest comparable figure, $1,013,728,780 was recorded during the same period in 1927.



Improvised Nuchar Feeding Apparatus at Newport News, Va., Consisting of Coca-Cola Barrel and Electric Drill Agitator

MECHANICS OF POWDERED ACTIVATED CARBON APPLICATION

By F. E. STUART
Industrial Chemical Sales Corp., Park Avenue, New York City

MOST American municipalities have similar problems to deal with in the clarification and purification of their water supplies. The assumption that tastes and odors which may develop in the water are a necessary evil is no longer acceptable. Since the development of powdered activated carbon, the water works operator has at his command a material that he can apply with little trouble to rid his supply of the objectionable tastes and odors. It is advantageous to understand the fundamental principles of activated carbon application and this paper has been prepared for the benefit of those interested in keeping abreast of developments in the practical application of activated carbon to water supplies.

Activated carbon is by no means a new material in the water field as it has been used abroad on a small scale for several years. The application of carbon in powdered form is, however, a comparatively recent development.

Application Methods Simple.—The mechanics of the application of powdered activated carbon are very simple and the benefits from its use many fold. The ideal method of application is by means of a suitable dry feed machine equipped with a water ejector which sucks in the carbon and delivers the suspension to the point of application. The volume of water involved is of no importance; it is merely the means of ensuring effective distribution of carbon through the water to be treated, as the powdered carbon mixes readily with water to produce an effective suspension. As soon as it becomes wet and the pores of the carbon thoroughly filled with the water in which it is held in suspension, it can be transported any distance desired without harming the absorptive properties. Another means of applying powdered carbon is to add it to the alum—either dry or in solution. If added to the solution tank, agitation must be provided during the periods of use in order to make a thorough distribution.

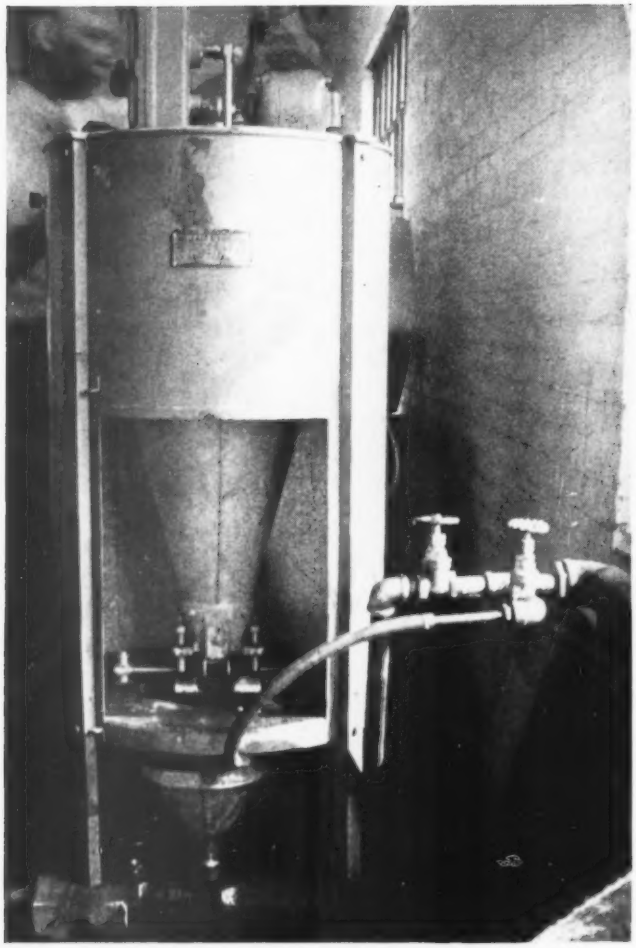
Point of Application.—The usual point of application of powdered carbon suspension is to the water leaving the mixing chambers and flowing to the coagulating basin where the carbon has a good contact period and settles out in the basin to some extent. The sludge-carbon mixture does not show the tendency to putrefaction exhibited by ordinary sludge and consequently periods between basin cleanings can be materially increased. This increase between basin cleanings saves the treated water, and there is, in addition, the absolute assurance that the putrescible material in the sludge will not create any taste or odor nuisance.

Some plants are using a split treatment applying part of the carbon to the raw water to stabilize the sludge that settles out in the coagulating and settling basins and the remainder to the water leaving the settling basins and flowing upon the filters. The carbon in suspension settles out upon the filters raising the filter efficiency. Contrary to the general belief that activated carbon settling out on the filters will greatly decrease the runs, it is now an established fact that an effective dose of activated carbon, applied in a thoroughly dispersed suspension to the filter influent will not materially decrease the length of the runs, and will also give a final filtered effluent superior to the ordinary rapid sand filter effluent.

The ordinary method of treatment entails the addition of powdered carbon to the settled water in the ratio of 10 to 15 lb. of carbon per million gallons of water. This amount has, in a great majority of cases, removed objectionable tastes and odors. However, there are some plants using from 20 to 30 lb. of carbon per million gallons of water, but they are plants with unusually severe problems.

Emergency Installation at Newport News, Va.—Recently, when the Newport News, Va., reservoir made a complete turnover, the water became so devoid of oxygen that all the fish died, and a very disagreeable odor and taste developed. An emergency outfit consisting of an ordinary Coca-Cola barrel equipped with an electric drill for agitating was used to feed powdered carbon to the filter influent at the rate of 2 parts per million and the taste and odor were completely eliminated from the water after nine hours operation.

One can readily see that the mechanics of powdered activated carbon application are very simple and can



W. & T. Type O Dry Feed Machine at Norfolk, Va., Feeding Into a 1¼ In. Penberthy Injector Operating on 40 Lb. With No Head or Vacuum Lift, Merely Pushing the Carbon to the Point of Application, Some 150 Ft. Distant

be varied to suit existing circumstances. It is only necessary to have a quantity of the material on hand so that when taste and odor troubles appear the superintendent is prepared to meet the problem.

Characteristics of Powdered Activated Carbon.—It appears that the affinity of impurities in the water is greater for carbon than for the solution in which they exist, and therefore the removal of taste and odor by means of carbon depends upon the phenomenon of physical attraction and requires no chemical balancing. The use of powdered carbon in no way interferes with other methods of chemical treatment, including moderate superchlorination or prechlorination. Contrary to common belief, powdered activated carbon in contact with prechlorinated water will not remove the residual chlorine, but it will remove all the residual upon percolation through filters containing some activated carbon. Why the finely divided carbon in suspension does not promptly remove residual chlorine is not readily explained, but the phenomenon has been observed in practice.

Another characteristic of powdered activated carbon which is contrary to present belief is its ability to absorb peculiar tastes and odors from sludge. It was first supposed that the sludge would entirely surround the pores of the carbon and choke it to such a degree that it would lose all of its adsorptive properties. However, once allowed to settle in the coagulated material, it remains in the sludge in the basin and creates a condition that has never been observed before in water purification. As mentioned previously, the carbon prevents the old sludge from imparting taste and odor to the overlying water.

How Some Cities Are Using Powdered Activated Carbon.—From contacts that the writer has had with a great many plants using powdered activated carbon, it is his firm belief that the use of this material will prove of great benefit to water works operators in their endeavors to produce a better product. Plants all over the country are beginning to see the benefit of applying small dosages of activated carbon to the raw water and allowing this material to settle out in the coagulation basin. Such cities as Toledo, O., Norfolk, Va., Hackensack, N. J., and Daytona Beach, Fla., find that the application of small amounts of activated carbon prior to coagulation is very beneficial and materially lengthens the time between basin cleanings. At Sandusky, O., powdered activated carbon is applied to the influent of the first mixing chamber. Some of the sludge containing carbon is returned to the raw water thus procuring re-use of the carbon. This process is practical and economical. Springfield, Ill., uses a similar type of recirculated carbonized sludge, and the new plant at Saginaw, Mich., uses it occasionally. The sludge serves to create artificial turbidity which in turn means better coagulation and the carbon present in the returned sludge remains active enough to stabilize the new sludge. A small quantity of fresh carbon is continuously applied to the raw water along with the returned sludge.

Powdered activated carbon is being used in softening

The Norfolk, Va., Installation Showing the 1½ In. Carbon Manifold Line With Four ¾ In. Gate Valves Discharging Into Their Respective Basins

plants to stabilize the great amount of sludge that settles out and in this way materially reduces the waste of treated water used for cleaning. Some softening plants are troubled with a caustic alkalinity taste and activated carbon is being used to remove this taste.

When a prechlorination dosage sufficient to leave a chlorine residual in the filter influent is used, it has been found in general practice that any taste created by the residual chlorine can be adsorbed by activated carbon on the filter beds and the filters will deliver a water that is free from tastes and odors, and which is bacteriologically safe. This method of treatment is one of the newest in the field, but it appears to have the greatest future.

LETTERS TO EDITOR

Standard Methods of Water Analysis

My dear Mr. Baylis:

I have read with a great deal of interest the section which you edit in WATER WORKS AND SEWERAGE, for the June, 1931, issue. I was particularly interested in your comments dealing with the discussions at the Pittsburgh American Water Works Association meeting on Standard Methods of Water Analyses. Inasmuch as I feel that your comments in this column are totally at variance with the facts, and create the impression that the Committee on Standard Methods of the American Public Health Association has been peculiarly delinquent, I feel that you should give some public indication that your impressions were erroneous.

You state that the Committee of the American Water Works Association on Standard Methods of Water Analysis has been unable "to get through more changes in the methods." As far as I am aware the Committee on Standard Methods of the American Water Works Association has submitted no changes to the Committee on Standard Methods of the American Public Health Association which have been ignored or refused.

You state that there seems to be a feeling that many good recommendations are being ignored by the A. P. H. A. Committee. Specifically what are these?

You note that there is considerable dissatisfaction among water works employees with the present Standard Methods. That is true, but that dissatisfaction should be expressed to the Committee of the American Water Works Association which Committee in turn should make itself articulate to the American Public Health Association. I think you should be quite aware that the Committee of the American Water Works Association has done no such thing up to the present writing. I believe that Mr. Hinman, who is Chairman of the Committee of the American Water Works Association, will confirm my statement of these facts.

As a member of the Committee on Water Works Practice of the American Water Works Association and Chairman of the Committee on Research and Standards of the American Public Health Association, I have not been aware that any recommendations made by the American Water Works Association have been ignored by the American Public Health Association Committee. In matters of this sort I do not feel that very much is gained by airing the situation in the public press, but inasmuch as your comments are so patently not in accordance with fact, I had no other recourse but to ask you to correct the impression given to the water works profession by giving full publicity to this letter in your column.

ABEL WOLMAN,
Chairman, Committee on Research and Standards,
American Public Health Association.

[Evidently Mr. Wolman has not attended some of the meetings of the Committee on Standard Methods of Water Analysis of the American Water Works Association that I have attended. The report of the Pittsburgh meetings was the impression gained after listening to the discussions of the committee. Perhaps those who felt as the report stated, did most of the talking and caused me to arrive at the conclusion that this was the sentiment of the entire committee. If I have misinterpreted the committee's feeling, I regret the remarks, but I do not think I have misstated the feeling of a number of the committee.

Mr. Wolman asks what recommendations are being ignored. This is not the proper place to discuss the matter. I shall give him my own experience as a member of the committee in a private letter.]—JOHN R. BAYLIS, Associate Editor.

Meter Reading and Billing

To the Editor:

Referring to your "Symposium of Practice," I note the communications in your WATER WORKS AND SEWERAGE for the month of August, 1931. I think it would be well to give our practice as it does not coincide with that of most of the replies I read in your August number.

We collect what we call large bills, that is for factories, larger stores, and otherwise where the bill amounts to above $5 or $10 a month, every month, and we find that very satisfactory as it precludes, at least in a measure, the claim of the owner or tenant that they should have received more prompt notice of a leak or leaks so that they could remedy same. It seems to me that the majority of those who have written you on the subject only render a bill once in three months, but we send out bills in all ordinary cases for houses, etc., every two months, and it works well, and I think would in a city of our size, 50,000 inhabitants, but it might not work so well in smaller or larger places.

I have been a water-works superintendent for 44 years and I think I should be able to say what would be advisable under the conditions where I work, but it looks to me that waiting for three months is altogether too long a time in which to have bills standing unless there is an advance payment made that would make the city good where there was a dispute and delay in paying. We formerly turned off water almost universally where the party did not pay at the end of the 45 days we allow from the date of the bill; but of late the commissioners have been more lenient and have allowed some people in somewhat destitute circumstances, to stave off payment for a considerable time hoping for better things.

We do not think we have made any great mistake in connection with our water works as it is worth about $2,000,000, has a larger pipe system than almost any city with which we are familiar, owes no indebtedness in the shape of bonds or otherwise, except current bills, and we have $160,000 in the water fund, and would have $200,000 if it was not for furnishing construction work for the park department.

It appears to me that there should be more uniformity in this matter of rendering bills for water, and that long intermission between bills is not advisable in most cases. —W. W. BRIGDEN, Superintendent and Engineer, Department of Public Works, Battle Creek, Mich.

DESIGN FEATURES OF NEW FILTER PLANT AT ERIE, PA.

By J. T. CAMPBELL

Member of Firm,
The J. N. Chester Engineers,
Pittsburgh, Pa.

THE new filter plant at Erie, Pa., known as the West Side filtration plant, became a necessity when the consumption of water in the summers of 1928 and 1929 approached the maximum capacity of the existing or Chestnut St. filtration plant. The intake at this plant is the limiting feature, being good for 37,000,000 gal. per day, while the maximum daily pumpage for 1929 amounted to 35,000,000 gal., which, however, did not equal the consumption, as the reservoir dropped during this period, and sprinkling had to be limited to certain hours in the early morning and evening.

General Features.—Water is taken from Lake Erie through a 72-in. riveted steel pipe line, laid from the low service pump station on the shore of the bay at Tracey Point, across the bay and through the peninsula, to a point in Lake Erie about 6,600 ft. north of the western extremity of the peninsula, where it terminates in a wooden crib 40 ft. square, by 17 ft. 6 in. deep. The top of this crib is 6 ft. above the lake bottom and has 25 ft. of water over it at mean lake level.

Water flows by gravity through the intake line into a wet well below the low service pump station where it is picked up by motor-driven centrifugal pumps, and discharged into mixing chambers which, together with the settling basins, filters, and high service pump station are located on a level plateau approximately 90 ft. above mean lake level, and at a distance of approximately 1,200 ft. of the low service pump station.

The mixing chambers, eight in number, are located alongside the two settling basins, a common wall separating them. The mixing chambers and settling basin are covered to prevent the formation of ice. The filters, coagulant house, and high service pump station form one continuous building which also houses the wash water tank, it being located beneath the dome over the coagulant house.

Future Extensions Considered in Design.—In the design of the plant, economy from the standpoint of future extension has been carefully considered. Where future extension of any element, such as filters and pumps, is a comparatively simple matter entailing no tearing down or modification of existing structures, these units have been designed for a 16,000,000 gal. per day rate. Where extensions are complicated and more costly in proportion to the increased capacity, these elements, such as settling basins and mixing chambers, have been designed for a 32,000,000 gal. per day rate. When future extensions are impossible, or exceedingly costly, such as in the case of the intake, pump station, buildings, etc., the basis of design has been the final or limiting capacity of the plant.

The Intake.—The intake, which has a capacity of 70,000,000 gal. per day, is a 72-in, riveted steel line, ½ in. thick, except for that portion under the peninsula, where its thickness has been increased to ¾ in., and circular angle reinforcing added. The pipe is dipped at the factory in a hot bath of bituminous coating, and every precaution is taken in transporting and laying this pipe to preserve this coating from injury. Flexibility at fixed points is obtained by a combination ball and expansion joint.

Remote Control of Pumps.—The low service pump station has been made large enough to house pumps to the capacity of the intake, but at the present time three low service pumps, one 16,000,000 and two 8,000,000 gals., have been installed. These units are operated

Construction View of West Side Filtration Plant of Erie, Pennsylvania

by remote control from the high service pump station in the following manner.

A push button on the control table, located on the balcony of the high service pump station throws into operation a vacuum pump in the low service pump room, thereby priming the low service pump. The resulting vacuum is recorded on a dial in front of the operator, and when the pump has been primed, it is automatically thrown into service and the vacuum pump shut down. The operator at his table notes on his ammeter the increase in the flow of current, which advises him that his vacuum pump is running, and further increase when the low service pump throws in. He can also, from his position, see the venturi meter indicator located on the floor of the high service pump station, which tells him that water is being pumped into the mixing chambers. Signal lights on the board indicate which pumps are running. The operator also, from his position at the control table, can by remote control throw on any of the high service pumps located on the floor beneath him. These pumps automatically prime themselves when the clear well level has reached a certain elevation, but additional means of priming vacuum pumps have been provided.

The voltage of the pump motors is 2,200, 3-phase, 60-cycle, and the electrical control equipment has been selected with the idea of safety first, Allis-Chalmers armor clad switch gear and Electric Control Manufacturing Co.'s controllers having been provided. These are self-contained units totally enclosed in metal casings with no wire or buss bars exposed, thereby eliminating the possibility of injury by contact with power wiring.

Mechanical Type Mixing Chambers.—Mixing chambers which are 20 ft. square by 21 ft. deep are of the mechanical type. They are provided with three horizontal revolving paddles each, the stirring device being operated by motor through a speed reducer. This stirring equipment has been designed to give a velocity of water of approximately 0.6 ft. per second, which we consider to be the optimum velocity for obtaining thorough mixing and production of heavy floc. The mixing chambers have been designed for 20-minute retention period for 32,000,000 gal. per day, but at the present time will have a capacity of 40 minutes since the plant will be operating at a 16,000,000 gal. per day rate.

The Settling Basins.—Settling basins have a retention period of three hours, for 32,000,000 gal. daily. These basins are located alongside the mixing chambers so as to prevent the floc being broken up as much as possible after it has formed, and to this end conduits for distributing the mixed water to each of the two settling basins have been designed to keep the velocity below 1 ft. per second. Perforated baffles at the inlet permit the water to enter the basin uniformly, and the travel of the water is straight across the basins to the opposite end, where the water is collected from the top through perforated baffle walls. There are no intermeditae baffles, and no changes in direction of travel, as we have found "around the end" baffling in settling basins will reduce the efficiency by over 30 per cent. Settling basins are drained through hand-operated plug valves located at intervals in the bottom approximately 40 ft. on centers.

The Filters.—The filters are in 2,000,000-gal. units with the sand area designed for filtration at 2 gal. per square foot per minute. The operating floor is level with the tops of the filter walls, with walks across and around the filters to afford observation during washing. These filters are provided with what is known as a false bottom 20 in. deep, which serves as a collecting and wash distribution system. The wash water is introduced into this area, and is distributed up through the gravel, and sand through bronze pipe and umbrella head strainers spaced on 6-in. centers over the entire false bottom. This type of bottom assures equal distribution of the wash water, and also permits inspection for loss of sand through the filter units due to unscrewed or defective strainer heads. Ten inches of gravel has been provided over the strainers varying in size from 1 to ⅛ in. and placed in layers, with the coarsest gravel on the bottom, and the fine on the top. This gravel is held in place by means of copper screens laid on top of the gravel, and held down by means of bolts and washers, which are screwed into the tops of the filter strainers. These holding down bolts are located 12 in. on centers. Thirty inches of sand has been provided over the gravel having an effective size of 0.44 millimeters, and a uniformity coefficient of 1.48.

The wash water system has been designed to give a maximum rate of wash of 22½ gal. per square foot per minute, which is equivalent to a 36-in. rise per minute. The tops of the troughs are placed 24 in. above the top of the sand, this distance having been decided upon after carrying out tests on the flotation of the sand under the above mentioned rate of wash. The wash water tank which is a steel structure having a capacity of 110,000 gal., is placed in the tower of the coagulant house. The steel columns supporting it have been carried down independently of the structural steel of the building proper, so as to avoid cracking of the walls and plaster in the event that the foundations of the wash tank settle more than the building foundations.

Filters are controlled from a master controller located on the master control table in the lobby. This master control is of the Vivian type, as manufactured by the Norwood Engineering Co., and automatically regulates the filtration rate of the individual filters.

The Clear Well.—A clear water well in two units has been provided under the entire length of the filters, these units being separated by the pipe gallery. This clear well has but a small capacity since it is only an equalizing basin between the low service and the high service pumpage. The water from the individual filters, in entering this clear well, must pass through a flume into which the chlorine is introduced. This flume is provided with a mixing chamber so as to thoroughly mix the filtered water with the chlorine. The chlorinated water then enters the clear well at one end, and the high service suctions take off from the extreme opposite ends of this well.

The construction work was begun in March, 1930, and it is expected that the plant will be in operation in October of this year. The entire cost of the plant, including the intake, will amount to $1,500,000.

Acknowledgement.—The foregoing is a paper presented June 26 at the 4th annual conference of the Pennsylvania Water Works Operators' Association.

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INSTALLING SERVICE BRANCHES AT CINCINNATI, O.—Under a method of installing service branches at Cincinnati, a contract is made covering the installation of the branches from the mains to the property line. Two years of trial have proven this a very satisfactory method.

SYMPOSIUM OF PRACTICE

WHO SHOULD OWN AND WHO SHOULD INSTALL WATER METERS

Duluth, Minn.

It is the practice of this department to furnish and install all meters, both for water and gas. Originally it was our practice to require the customer to furnish and pay for the meters for his own premises. This practice was changed in 1915, at which time the department purchased from its customers their meters at a price determined by the then market price, less depreciation.

There are many reasons why I believe our present practice superior to our former one:

The requirement of universal metering comes with better grace if the utility furnishes the meters.

The utility is in full control of make and type of meters.

The customer has no objection to the department's testing and overhauling meters at any time. When it is desired to overhaul or test a meter, it is simplest to remove the meter in question and set a new one, and when the meter is ovrhauled it is simply replaced on the shelf ready to be installed in some new premises. When the customer owns the meter it is necessary to reinstall his old identical meter.—E. W. Kelly, Manager, Water and Light Department, Duluth, Minn.

Minneapolis, Minn.

The city of Minneapolis purchases meters for stock from which they are sold to the water consumer. They are set in place by licensed plumbers and brought in by them in cases where the removal involves a leak. In cases of stoppage or trouble with the meter itself, they are brought in by the department. The city makes all repairs charging only for the parts used. The purpose is to safeguard the city in the matter of kinds of meters used, to keep them in good order at low cost and make metering popular. We are not prepared to say which is the better method, but believe that by our present procedure we have a satisfactory control of the meter practice in this city.—J. A. Jensen, Engineer of Water Works, Minneapolis.

Kenosha, Wis.

Prior to Jan. 1, 1931, the rules of the water department provided that the water consumer must either purchase or rent the meter from the Water Department in order to obtain service. On Jan. 1, 1931, the Wisconsin Public Utilities Commission on application from one of our consumers, made a ruling directing the water department to provide meters for all consumers. This order also provided that the water department must purchase all of the consumer meters installed in the 30-year period prior to Jan. 1, 1931, at a price based on the unamortized value of these meters. This order is based on the principle that a utility should provide the measuring device on which the bills rendered are based. Pursuant to this order, the City of Kenosha Water Department now furnishes and sets, free of cost to the consumer, all water meters. Also under this order, we are compelled to maintain all meters except meters that are damaged either by frost or hot water. Meters so damaged, are repaired by the water department at the expense of the consumer. The water department has always set all of the meters; however prior to the order of Jan. 1, 1931, a charge was made for this setting.

We are very much in favor of this order of the Public Utilities Commission, in that it gives us more freedom in testing and replacing meters that are under registering. Also we need not feel at all concerned as to whether or not the consumer, after the meter is tested, receives the same meter in return, which was quite necessary under the plan of the consumers owning the meters.—P. J. Hurtgen, Director of Public Works, Kenosha, Wis.

Campbell, Calif.

We are very much opposed to consumers owning their meters as our experience has been that they do not take care of them and when we do the repairing and cleaning of meter it is difficult to collect from the consumer. Besides we do not receive the revenue from the meter charge and there are many small expenses which the water company is required to take care of and no collection can be made. We have a little over 600 meters in Campbell and all except three are owned and controlled by the Campbell Water Co. Our men are trained in the care and proper attention to meters and we would much prefer to own and care for them. We are now insisting on the Campbell Water Co. owning the meters as we believe it is much better for both parties.—Ralph N. Hyde, Vice-President, Campbell Water Co.

Council Bluffs, Ia.

We own, set and remove and maintain all meters and the only charge made is for damage to meters caused by hot water or from frost. We read the business section and all large meters every 30 days and the residence meters every 60 days.—F. S. Haas, Secretary, City Water Works, Council Bluffs, Ia.

Boston, Mass.

The water division of the Metropolitan District Commission furnishes water to the 20 cities and towns that comprises the Boston Metropolitan Water District but the distribution of the water is entirely in the hands of the local town or city officials. Each city or town distributes the water to the consumer, supplies and sets me-

ters, establishes and collects the water rate and appears to be satisfied with this method of operating the water systems.—John L. Howard, Deputy Chief Engineer, Water Division, Metropolitan District Commission, Boston, Mass.

London, Ont.

Our opinion has always been that the only logical ownership of water meters is by the department. Naturally ownership also implies installation and maintenance. It seems to be just as ridiculous to expect that the consumer of water should provide the meter as it does for a customer at a grocery store to provide his own scales. I have never heard of any gas or electric utility allowing its consumers to provide their own meters, why therefore should water utilities consider such a proposal.

In the accompanying schedule of water rates, it will be noted that our rate is a service charge which, of course, includes an amount for meter expenses. All water is paid for on a sliding scale as registered.

SCHEDULE OF WATER RATES AS REVISED FEB. 19, 1925

SERVICE CHARGE

½-in. meter	$ 1.25	gross bi-monthly
¾-in. meter	1.87	gross bi-monthly
1 -in. meter	2.50	gross bi-monthly
1½-in. meter	3.75	gross bi-monthly
2 -in. meter	5.00	gross bi-monthly
3 -in. meter	7.50	gross bi-monthly
4 -in. meter	10.00	gross bi-monthly
6 -in. meter	15.00	gross bi-monthly

RATES FOR WATER CONSUMED

Up to 10,000 cu. ft. bi-monthly	$0.15	per 100 cu. ft. gross
Further amount over 10,000 and up to 20,000 cu. ft.	.12½	per 100 cu. ft. gross
20,000 and up to 34,000 cu. ft.	.10	per 100 cu. ft. gross
34,000 cu. ft. bi-monthly	.08	per 100 cu. ft. gross

DISCOUNT

A discount of 20 per cent is allowed for prompt payment on due date, as specified on bill.—Thomas Hodkinson, Superintendent of Water Works, London, Ont.

Seguin, Tex.

Meters always should be owned by the Water Department. The ordinance adopted Nov. 4, 1930 by the city council of Seguin contains the following sections relating to ownership of meters:

"The city will supply and maintain all meters without charge except when a meter larger than three-quarters of an inch is necessary the consumer shall have the option of paying the full cost of the meter and its installation and, thereby remain on the low minimum monthly charge. The low minimum is One Dollar per month within the city limits, and One Dollar and Twenty-five Cents ($1.25) per month outside of the city limits."

"a. All meters furnished by the City of Seguin shall remain at all times the property of the City of Seguin, and shall be maintained and repaired, when rendered unserviceable by fair wear and tear, or renewed, by the City."

"b. When replacement, repairs, or adjustments of any meter are rendered necessary by the act, neglect or carelessness of the owner or occupant of any premises, any expenses caused to the City thereby, shall be charged against and collected from the owner or occupant of the premises, and if not paid by regulation due date, all service shall be discontinued."—H. B. Iglehart, Manager of Utilities, Seguin, Tex.

Columbia, S. C.

Our consumers are charged the installation and tap fee in which is included the cost of the meter. However, the meter remains the property of the city for two very good reasons: First, the private parties should not be permitted to make their own connections as results might prove disastrous; and, second, because ownership of the meter is a margin of safety in collecting bills. To illustrate the second point—A property owner has a bill of $10.00 outstanding when the mortgagee forecloses and kicks on having to pay the past due account. The mortgagee is informed that he does not have to pay the past due account but that he will be permitted to open up a new account upon the payment of $20.00 meter fee. This plan is also of benefit to the city in landlord and tenant cases. In other words, if you never let a bill get over the amount of your meter fee you cannot lose. —Edward P. Hodges, Commissioner of Water.

Miami, Fla.

We believe that all water meters should be owned by the company. The fact of the matter is the water company should own the service pipe from the water main which is in the street up to and including the meter. The water company should own the meter as well as the meter box and the curb cock. The water meter is usually placed just inside the curb line. The consumer should bring his service pipe from the house to the meter connection. The water company should own the meter so that in case of non-payment the water supply can be shut off and make it possible for the water company to test the meter whenever it so desires. The water meter should be sealed by the company's seal so as to eliminate the possibility of tampering. The service lines, meters and meter boxes are part of capital expense and the water rates should be designed so that these facilities are a part of the rate base the same as other property of the water company.—H. H. Hyman, Division Manager, Miami Water Co., Miami, Fla.

East Point, Ga.

The rules governing the meter situation in East Point, Ga., are as follows: First the person desiring the water connection to any lot or place of business makes application for the service and the size. The application is accompanied with check for the full amount of the price of service. Then the city places the meter on the city's property, which is the grass plot between the curb and the sidewalk. When installed on this particular piece of property neither the city or the property owner can remove it.—C. E. Hutcheson, Superintendent Water and Light Department.

Warren, O.

The water department owns all the meters and maintains them providing they are not damaged by freezing or by hot water. We do not see how water meters can properly be taken care of when they are owned by the property owner. With us here if we think a meter is not registering properly we change it for another meter that has just been tested and then do whatever is necessary to the one removed and it is then placed on another service. In this way it saves one trip with the meter man and we are at liberty at any time to remove, test or repair as we see fit.—C. E. Inman, Superintendent of Water Works.

Montreal, Que.

The city owns and sets all its water meters, charging rental according to size. The following extract shows the rental rates:

RATES

DWELLING HOUSES, STORES, SHOPS, OFFICES, ETC.—6 per cent on the annual assessed rental; CHURCHES—6 per cent on rental based on 4 per cent of assessed value. HOTELS, TAVERNS AND RESTAURANTS—12 per cent on the annual assessed rental; HORSES—$2 each; COWS—$1 each; HORSE STALLS—$1.50 for each stall whether occupied or unoccupied; PUBLIC BATHS—$6 each tub; METER RATES—Abattoirs, breweries, cold storage plants, dairies, distilleries, dye-houses, public garages, railways, certain manufacturing establishments, academies, nunneries or convents, etc., $1.15 per 1,000 cubic feet; METER RENT—per annum—½-in. $2, ⅝-in. $2, ¾-in. $3, 1-in. $4, 1½-in. $8, 2-in., $12, 3-in. $25, 4-in. $40, 6-in. $75, 8-in. $100. Meter Rates—Water supplied by meter is payable quarterly.

DATE OF PAYMENT

The water rates are due and payable on the 1ST DAY OF SEPTEMBER in each year up to which date there will be allowed a DISCOUNT OF 3 PER CENT.

BUSINESS TAX

The rate of Business Tax is 8½ per cent on the annual assessed rental of the premises occupied: BREWERS—The Business Tax on Brewers is $60 for every $400 assessed or part of $400; DISTILLERS—The Business Tax on Distillers is $80 for every $400 assessed rental or part of $400; SPECIAL TAXES—Banks—on capital up to $1,000,000, $400; $1,000,000 to $2,000,000, $500; above $2,000,000, $600; Banks—branches—each, $100.

Life Insurance	$200
Accident and Sickness Insurance	200
Health Insurance	200
Cattle Insurance	200
Plate Glass and Boiler Insurance	200
Insurance against burglary	200
Guarantee and Employers' Liability Insurance	200
Automobile Insurance	200
Marine Insurance	100

When one company combines two of the above branches of insurance only one tax is paid. Fire Insurance—Tax on premium 1 per cent (minimum $200).

HOTELS, RESTAURANTS AND CLUBS on an assessed rental of

$160 and under	$27.00	$ 700 to 800	$101.25
160 to 240	36.00	800 to 1000	112.50
240 to 320	45.00	1000 to 1200	123.75
320 to 400	56.25	1200 to 1600	135.00
400 to 500	67.50	1600 to 2000	157.00
500 to 600	78.75	2000 to 2400	175.00
600 to 700	90.00		

with an increase of $17.50 for each $400 or fraction thereof above $2,400.—J. A. Jette, Engineer Superintendent of Canalisation.

Lewiston, Idaho

The city of Lewiston buys and installs all meters at no charge to the consumer. We have a shop equipped for meter testing and repairing and feel the city is in a better position to take care of this than by the consumer. A few years ago in Coeur d'Alene a private company started to charge the consumer for the service line, meter, etc., but a suit was brought by the consumer who had it carried to the Supreme Court and won.—W. P. Hughes, City Engineer and Superintendent of Water Works.

Winona, Miss.

In our opinion the water company should own and install all water meters. We cannot understand why the customer should own or install water meters, any more than a customer of a grocery store should own scales for weighing groceries.—H. E. Johnson, Manager, Winona Public Utility, Winona, Miss.

Washington, Ind.

It is the policy of this company to own all meters and install same at the company's expense; however, each consumer is required to make a security deposit, same to be refunded when their service is discontinued and all bills paid.—E. F. Jones, Manager, Indiana Water Works Co., Washington, Ind.

Winnipeg, Man.

The water works in Winnipeg are owned by the city. We are metered 100 per cent. There are at this date 39,000 meters in use which are owned, installed and maintained by the city free of cost to the water consumer.—Thos. H. Hoopes, Superintendent of Water Works.

Wilmington, Del.

The city of Wilmington owns all water meters except the detector meters used on fire lines. The water department also sets all meters free of charge, except the fire line meters.—S. N. Van Trump, Chief Engineer, Water Department, Wilmington, Del.

Fredericksburg, Va.

Our water department owns and maintains all water meters. Personally, I cannot understand why anyone should ever feel that a water meter should be owned by the customer, any more so than the customer should own and maintain its gas meter.—L. J. Houston, Jr., City Manager.

Birmingham, Ala.

The Alabama Water Service Co. has always owned, set and maintained their meters as it is felt that all revenue producing instruments should be the property of the company.—J. M. Jackson, Jr., Secretary, Alabama Water Service Co.

Denver, Colo.

Meters are owned by the consumers in Denver, and all repairs are paid for by the consumer.—Geo. F. Hughes, Assistant Manager, Board of Water Commissioners, Denver.

Marquette, Mich.

The water department owns the meters and does all setting and repairing.—Wm. J. Johnston, Superintendent of Water Works.

Streator, Ill.

We own, set, test and maintain all meters in this city. —R. D. Huggans, Superintendent, Illinois Water Service Co., Streator, Ill.

Portland, Ore.

For many years, the Bureau of Water Works of Portland, Ore., permitted plumbers to lay service pipes from the main to premises to be served after a tap had been inserted in the main by water works employees. This practice has been discontinued, and the bureau

now installs services of all sizes from the main to the property line at the following rates:

Sec. 7. RATES CHARGED. The rates to be charged for laying and constructing such service pipes by the Bureau of Water Works shall be as follows:

Size of Pipe	Dirt Street	Gravel or Macadam	Paved	Cost of each additional foot in excess of 18 feet: Dirt Street	Gravel or Macadam	Paved
¾-in.	$ 25.00	$ 32.50	$ 37.50	$0.30	$0.50	$1.00
1 -in.	30.00	37.50	42.50	0.35	0.55	1.10
1¼-in.	65.00	70.00	75.00	0.40	0.65	1.30
1½-in.	75.00	80.00	85.00	0.50	0.70	1.40
2 -in.	100.00	105.00	110.00	0.60	0.80	1.60

The same rule applied as to the setting of privately owned meters. Plumbers were allowed to set such meters and like the laying of service pipes, there was no end of grief. Plumbers would not back-fill the trenches properly; the pavement would settle, and the water works was blamed. The same trouble was found to exist when plumbers installed private meters. (In this city, all meters are set at the street curb, and Portland is 100 per cent metered.) Plumbers would set the meters too high or too low in most instances, and in many cases, were indifferent in replacing the concrete around the meter boxes, thus allowing water to enter basements and cause damage to goods stored therein.

We now install all meters. The city owns all meters up to and including 1 in. in diameter. Meters of over 1 in. in diameter must be purchased by the property owners, and the cost of setting same is actual cost of labor and material furnished, plus 15 per cent for overhead, such as superintendence, billing, etc.

The writer believes that all meters regardless of size, should be owned by the water department for the following reasons:

First: There are a lot of different makes of meters on the market, and the water department should do the buying and not the consumer.

Second: For instance, if a water consumer lays a 4-in. pipe to a laundry for future use, but for the present, only needs a 2-in. pipe, we would much rather supply his wants through a battery of meters and install a number of 2-in. meters as needed, rather than one 4-in. meter. We get a more accurate registration of water used. Also, in case of a meter getting out of order, such an arrangement prevents a shut-down of the laundry.

Third: Meters are apt to need repairs at any time. When meters are owned by water consumers, the water department makes all repairs. Individuals, if they knew how to repair meters, could not be trusted to do such work unless the meters were tested by the water department employees before being again placed in service; when bills are presented for this work, consumers in many cases object to paying the bills.

Fourth: Meters become obsolete like any other piece of machinery, and the water department should be the sole judge when replacements should be made, or when they should be cleaned.

The proper method, we think, is for the water department to own and install all meters and make a monthly stand-by charge in addition to the charge for water used, based on perhaps a ten per cent charge of the original cost of the meter.—L. S. Kaiser, Superintendent, Bureau of Water, Portland, Ore.

Lake City, Minn.

All water meters in our city are owned by the consumers. The same is true of all light meters. My personal opinion is that all meters should be owned by the city or by the company serving the city. We, as a city, are selling our product the same as a merchant. He has to furnish means for measuring his product so why should not the city do the same.—M. J. Howe, Superintendent, Board of Water Commissioners.

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Artesian Water Supply of Memphis

Memphis is one of the largest cities in the United States that obtains its entire water supply from wells. The first deep well in Mimphis was drilled for the Bohlen-Huse Ice Co. in 1886, but no interest was aroused until another well 354 ft. deep drilled for the same company in 1887, proved to be a flowing well. After having passed through a stratum of clay 150 ft. thick, this well reached water-bearing sand, the source of the present supply, the water from which rose several feet above the surface of the ground.

Immediately wells were drilled for other industrial plants in Memphis and for the city supply, and in May, 1889, there were in the city 57 wells more than 185 ft. in depth—32 city wells and 25 private wells. Although no records exist of the number of wells drilled or the quantity of water pumped by private concerns during subsequent years, information gathered from old drillers in the region indicates that practically every plant requiring a supply of water of more than 10,000 gal. a day was equipped with its own well. In 1928 there were 86 private plants with wells.

Developments by the Memphis Artesian Water Department.—Forty-two wells were drilled for the public supply during 1888 and 1889, and the Auction Ave. pumping station was put into operation in 1890. The Auction Ave. plant included a tunnel 5 ft. in diameter and several smaller branching tunnels, 75 to 80 ft. below the surface. The wells discharged directly into these tunnels, and the water flowed by gravity to a central suction well at the pumping station, which is locally called the "wet well." High-duty pumping engines pumped the water from the central well and delivered it under pressure directly to the service mains.

In 1903 the waterworks were purchased by the city, and the Memphis Artesian Water Department was organized, under the supervision of a board of water commissioners. New wells were drilled from time to time as old wells failed and as additional supplies of water were required, but no change was made in the system until 1907. By that time the Auction Ave. plant had become inadequate, and during 1907 and 1908 a new pumping station was built at Central Ave.

Prior to 1907 the Artesian Water Department had done some experimenting with segregated pumps. By 1910 the feasibility of these pumps had been demonstrated, and several installations were made at different points about the city. Ultimately 14 such installations were available for use. They served to handle peak loads and heavy local drafts.

The present supply is obtained from 23 wells 375 to 550 ft. deep and 9 wells about 1,400 ft. deep. The shallower wells are located at intervals of 500 ft. along or near North Parkway. The deep wells are located at the sites of some of the other wells. The water is lifted from the wells by compressed air and flows by gravity through a duplicate system of mains to the pumping station at North Parkway and Dunlap St., where it is aerated and filtered and then pumped directly into the delivery mains.

N. Y. RULES AND REGULATIONS FOR INSTITUTIONAL AND PRIVATE SEWER SYSTEMS

THE New York State Department of Health, of which C. A. Molmquist is Director of the Division of Sanitation, has issued the 1931 edition of its rules and regulations for the preparation and submission of plans for systems and sewerage and sewage and waste disposal. A number of revisions have been made for the 1931 edition, which covers the rules and regulations for municipal systems, for institutional and private systems and for industrial systems. That portion relating to industrial and private systems follows:

Applications for the approval of plans for the construction, modification and extension of sewers and sewage disposal works for institutions and private buildings and for the issuance of a permit for the discharge of sewage from the proposed sewer or sewage disposal works must also be submitted to the state commissioner of health on blanks furnished by him, and must be signed by the owners, or the body having charge, of the institutions or buildings. In the case of corporations the application must be signed by the proper official of the corporation, with his official title. An application will be accepted from the designing engineer or architect or other agent only when accompanied by a proper letter of authorization.

All applications must be accompanied by plans, specifications and a report describing the system in detail. The plans must be in duplicate and the set intended for filing with the state department of health must be blueprints on cloth, black or colored line prints on cloth, or original drawings on cloth. If approved, one set, stamped with the approval of the state department of health will be returned to the applicant. If not approved, one set will in general be retained for record and the other returned to the applicant. Tracings will not be approved.

The approval of the state department of health is not required by law for pipes or drains designed and used exclusively for the removal of storm water or subsoil water or for other purposes of drainage where no sewage or wastes are allowed to enter them.

General Plans.—A general plan to a scale of 20 to 50 ft. to 1 in. should be submitted showing (a) topography by contour lines or sufficient elevations to indicate the slope and general topography of the ground; (b) all property lines including streets or roads; (c) buildings; (d) existing and proposed sewer lines giving sizes, character of material of which they are to be built, slopes, and elevation of the surface of the ground and of the sewer inverts at all points of change of grade or alignment; (e) existing and proposed sewage disposal works, pumping stations, manholes, outlets and other appurtenances; (f) the location and direction of flow of all streams with elevations of stream beds and of the high and low water elevations; (g) the location of all wells within 200 ft. of any sewage disposal works or within 100 ft. of any sewer line. In addition, there should be shown a diagrammatic profile for the entire installation including buildings, sewers and the units of the disposal works showing elevations, distances and other pertinent data. The plans must be accompanied by a topographic map of the United States Geological Survey in all cases where these maps have been published upon which must be shown the location of the property and point of discharge of the outfall sewer.

In general and especially where any unusual condition or design is contemplated, it is desirable to submit for informal consideration, in advance of the submission of final complete plans, preliminary plans accompanied by a report giving all the information necessary for a full understanding of the project. Favorable consideration of such preliminary plans must not be misconstrued as official approval nor as a waiver of the requirement for submission and approval of complete plans. Plans are approved only when they bear the department approval stamp and the signature of a qualified official of the state department of health.

Letterings, Figures and Symbols.—The lettering and figures must be of appropriate size and of distinct outline. The elevation of the surface of the ground and

Fig. 1—Example of Lettering and Symbols to Be Used

the sewer inverts should be clearly written near each manhole and flushing manhole and the length, size, slope and direction of flow indicated by proper lettering and symbols placed near the sewer lines between the manholes (see Fig. 1). A suitable title should be provided and the name of the city, village or town and the county in which the system is located, the name of the owner or owners or governing board, the scale, datum plane, key to symbols, the date, the engineer's license number, or if an architect his registration number, and the north point should be clearly indicated.

Profiles.—Profiles showing all sewers 8 in. and more in diameter and all main trunk lines and outfall sewers should be submitted with the plans. Profiles should have a horizontal scale at least equal to that of the general plan and a vertical scale not less than 10 ft. to 1 in. Both scales should be clearly indicated. They should show all manholes, inverted siphons, stream crossings and other important features and, numerically, all principal elevations.

Detailed Plans.—Detailed plans, including necessary cross sections to suitable scales, of all units of the sewage treatment works and appurtenances, together with information must be furnished giving dimensions, sizes, etc.

Specifications and Estimates of Cost.—A copy of the specifications for the construction of the work, with an estimate of cost, should accompany the plans.

Report.—The plans should be accompanied by an

engineering report giving a full description of the system or disposal works; the exact name of the individual, corporation or governing body owning or controlling the property and, in the case of schools, the number of the school district; the character of the property, school or institution; the present and estimated future population to be served and, in case of schools, the seating capacity and present enrollment; the name of, and distance to, the nearest stream or other body of water, and the volume of flow; the measured or estimated daily water consumption; a statement as to the use of any automatic flushing devices in connection with waterclosets or urinals, frequency of flushing and amount of water used; the use, if any, of shower baths; the source and adequacy of the water supply and, if the supply is from a well, the depth of well, nature and depth of the various strata of soil penetrated, depth and size of casing if the well is drilled, and the motive power used for pumping the water; the proposed method of removing and disposing of the sludge from the disposal plant; the depth of the ground water below the surface of the ground; and a statement as to the nature of the soil (clay, gravel, etc.) at the site of the disposal plant, to the depth directly affected by the method of treatment.

Sewers.—The state department of health will approve only of sewerage systems designed on the separate plan from which all rain water from roofs and other areas is entirely excluded from sewers tributary to the sewage treatment works.

In general, the sewerage system should be designed for the future population of the institution which it is estimated will be tributary to the system during a period of not less than one, and preferably two, decades. Lateral or main sewers should be designed with capacities, when running full, of not less than ten times the average estimated daily flow of sewage. Outfall sewers should be designed for capacities, when running full, or not less than five times the average estimated daily flow of sewage. Sewage and sewage effluent pipes which discharge into streams or other bodies of water should have their outlet ends terminate below low water mark. Sewers carrying raw or untreated sewage should be at least 6 in. in diameter and have slopes of at least ⅛-in. to the foot (1.0 per cent). In smaller installations 4-in. sewers with slopes of ¼-in. to the foot are acceptable for carrying settled sewage. In general all sewers should be designed with hydraulic slopes which will give mean velocities, when flowing full or half full, of not less than 2.0 ft. per second, based on Kutter's formula with n = .013. Under exceptional conditions, if full and justifiable reasons are given for it and if special arrangements are available or will be provided for flushing, velocities under 2.0 ft. per second (as low as 1.5 ft. per second) will be permitted. In general the following minimum grades should be provided:

	Per Cent
8 in. sewers	0.40
10 in. sewers	0.28
12 in. sewers	0.22
15 in. sewers	0.15
18 in. sewers	0.12
24 in. sewers	0.08

The use of a large sewer on a flat slope to comply with the above minimum slopes, when there is not enough sewage to fill the sewer nearly one-half full, is not generally advisable. Sewer lines must be laid on straight alignment and uniform slope between manholes. Manholes should be placed on sewers at all points of change of slope or alignment, at the upper ends of all sewer lines and otherwise at intervals not greater than 300 ft. apart. If the topography is very uneven and frequent changes in alignment and slope are necessary, a limited number of lamp holes may be substituted in the place of manholes at such points of change. Not more than one lamphole should be placed between two successive manholes. While no general statement can be made to cover all cases, it is generally expected that no sewer lines shall pass within 25 ft. of a well or other source of water supply, and that all sewers within 100 ft. of such sources of water supply shall be of cast-iron pipe with water-tight leaded joints.

Sewage Disposal

In general sewage disposal works should be designed for the estimated ultimate population for which the sewerage system is designed. If it is proposed to omit certain portions of the sewage disposal works for the complete purification of the sewage, there must be shown upon the plans a reserve area and the general character and arrangement of the works which it is proposed to install in the future when such complete works are required. There must also be included in the engineer's report the full reasons why such portions of the complete works are temporarily omitted.

Sewage disposal works should be located at as great a distance as practicable from buildings and from wells or other sources of water supply. In general, the state department of health will approve only of plans for such sewage treatment works as will produce a clear and stable effluent. This requirement may be increased or diminished according to local conditions, the volume and use of the stream below the point of discharge, and the necessity for protecting water supplies, bathing places, etc. In general the plans will be examined on the basis of the sewage flows noted in the following table:

	Gal. per day per person
Camps	25
Small dwellings, farmhouses, summer cottages, etc.	40
Large dwellings, boarding schools, etc., with numerous fixtures	75
Institutions (except hospitals)	100
Hospitals	150-250
Day schools	15
Day schools with showers	20
Factories	25

In institutions, hotels, schools with lunch rooms or other places where the volume of kitchen wastes is relatively large, grease traps of adequate capacity and suitable design should be provided on the waste lines from kitchen. On the basis referred to, the various parts of such sewage disposal works as are included below should, unless justifiable reasons are given for any deviations, conform with the following requirements:

Pumping Plants.—Pumping plants should be provided with at least two units each capable of pumping the maximum flow of sewage when either unit is out of service. Motive power should be available from at least two sources. The entire pumping plant should be properly housed and, in the case of electrically driven pumps, the motors should in general be located above the ground floor. All pumps for raw sewage should be preceded by bar or basket screens or settling tanks unless a special type of pump not requiring such protection is used.

Settling Tanks.—Settling tanks may be of such types as plain settling or septic, two-story or Imhoff, or separate sedimentation with separate sludge digestion. Plain settling or septic tanks for a single family dwelling, or for small institutions with populations of less than 25 persons, or for day schools with populations less than 100, should have capacities below the flow line of not less than one day's flow of sewage based upon the per

capita rates previously specified, the minimum desirable size of tank being 300 gal. For dwellings, institutions and day schools having greater populations these tanks may have capacities proportionally reduced. In the case of day schools the following capacities are satisfactory.

For Populations 100 to 150	¾ day's sewage flow
For populations 150 to 200	2/3 day's sewage flow
For populations 200 and over	½ day's sewage flow

For the smaller installations, designed to serve less than 1,000 persons, where 2-story or Imhoff tanks or sedimentation tanks with separate sludge digestion tanks are used, the detention period of the sedimentation compartment, and the capacity of the sludge digestion chamber should be not less than twice those required for municipal systems. Installations serving larger populations may be designed on the same basis as municipal systems.

Subsurface Irrigation Systems.—Subsurface irrigation systems should be preceded in all cases by settling tanks and, for the larger systems, be divided into not less than two sections so arranged that one section may be put out of service for periods of rest. In general the required length of tile should be based upon percolation tests of the soil on the site. The test in each case should be made by first digging a hole 1 ft. square and 18 in. deep (the depth of the tile trenches) and then filling the hole with water to a depth of 6 in. The downward rate of percolation or drop of water surface should then be observed taking the average time in minutes for the water surface to lower 1 in. in the hole.

To eliminate the effect of a dry soil the test should be repeated and the slower rate of percolation used. With this information, the rate at which the sewage may be applied to the total superficial bottom area of the trenches in which the tile is laid may be taken from the following table:

Time for water to fall 1 in.	Allowable rate of sewage application per sq. ft. Gal. per day
1 minute	4.0
2 minutes	3.2
5 minutes	2.4
10 minutes	1.7
30 minutes	0.8
60 minutes	0.6

The 4.0 gal. rate of application should be the maximum used for any installation. A test showing a rate of percolation slower than one hour would indicate that this method of disposal is not suitable.

On the basis of a sewage flow of 100 gal. per person per day and a trench 1 ft. wide, approximately the following lengths of tile per person will be required in the types of soil indicated:

	Per Person
Clean coarse sand or gravel	25 ft.
Fine sand or light loam	40 ft.
Fine sand with some clay or loam	60 ft.
Clay with some sand or gravel	165 ft.
Heavy clay	unsuitable

Soil samples must be submitted.

Main distributors should have diameters not less than 4 in. and be laid with tight joints on uniform slopes not greater than 1 per cent, or approximately ⅛ in. per foot. Lateral distributors comprising the tile field should be laid in trenches not less than 1 ft. wide nor more than 3 ft. wide and 18 in. deep and 4 to 9 ft. apart. They should have diameters of 4 in. and be laid on uniform slopes not greater than 0.5 per cent, with open joints ⅛ to ¼ in. wide protected with strips of tar paper 4 in. wide laid over the top and two-thirds around the circumference of pipe, the entire pipe to be surrounded by gravel or broken stone of graded sizes, from a level 2 in. below the bottom of the tile to a level 4 in. above the top of the tile. All lateral distributors should be laid so that the tops are from 12 to 18 in. below the surface of the ground, the branch connections between main and lateral distributors being made with a "Y," the connecting joints of which should be watertight.

Dosing tanks, if used and as is customary with large plants, should be equipped with automatic siphons and have a net capacity approximately equal to, but not greater than, three-fourths of the interior capacity of the pipe in the portion of the subsurface irrigation which is dosed at one time.

Leaching Cesspools.—Leaching cesspools may be used for private residences and institutions of small populations and are usually preferable where the soil below a depth of 2 or 3 ft. is more porous than that above this depth and where the subsoil is fairly well drained. They should be preceded by a settling tank. Leaching cesspools should be constructed of hollow tile, hollow brick or of dry rubble masonry, etc., of durable material and construction, should be placed not closer than 20 ft. apart out to out of walls and be arranged in groups running generally parallel to contour lines. The total number and size of cesspools for private houses and institutions occupied during the 24 hours and for day schools or institutions occupied only through the daytime should be such as to provide a total superficial percolating area above the ground water table in square feet, including bottoms and exterior side walls below flow lines, equivalent to not less than 75 per cent of that required for subsurface irrigation fields for the different classes of soil specified, or as may be empirically determined by the percolation test described. In the case of a percolating test, however, the test hole should be dug in the bottom of a pit excavated to a depth of about one-half the proposed depth of the cesspool. Soil samples must be submitted.

Artificial Subsurface Filtration.—Artificial sand filter trenches or subsurface sand filter beds should be designed for a rate of filtration not greater than 50,000 gal. per acre per day. The filtering material should be a coarse, clean sand having approximately an effective size between 0.2 and 0.5 millimeters and a uniformity coefficient preferably not over 3.0 and should be 3 ft. deep measured between center lines of the distributors and underdrains. A representative sample of the sand (at least 2 lb. in quantity) that it is proposed to use must be submitted with the plans. The distributing tile and underdrains should be laid entirely in coarse gravel or crushed stone spaced approximately 6 ft. on centers and in the case of filter beds the underdrains should be spaced midway between the distributors.

Intermittent Sand Beds and Trickling Filters.—Where, for special reasons, these methods of disposal are used, plans for them should in general conform with the requirements relating to municipal systems for these methods of disposal, except that the rates of filtration should be not greater than 50 per cent to 75 per cent, depending upon local factors, of those required for municipal systems.

Samples of Soil from Sewage Disposal Site.—Representative samples of soil at the site of disposal works, taken at the depth of the proposed trench in the case of subsurface irrigation systems, and of 4 to 6 ft. in the case of cesspools, should be submitted with the plans, the amount of soil in each sample to be not less than 1 lb. and placed in suitable, tight containers.

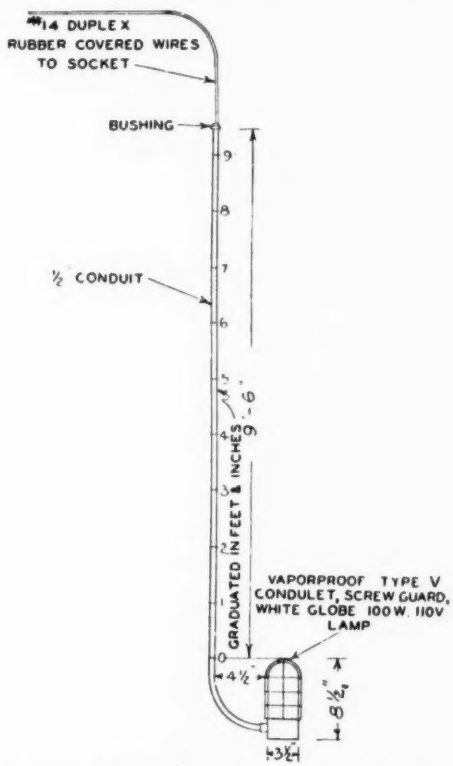
HOW THE SAND EXPANSION TEST IS USED FOR CONTROLLING WASH WATER RATES

By GEO. F. GILKISON
Chief Chemist, Kansas City Water Department, Kansas City, Mo.

A VAPOR proof light fixture and a piece of conduit is all the equipment needed for the test. The object of the test is to determine the expansion of the sand bed in inches, or percentage, while it is being washed. The vapor proof light fixture is mounted on a 10 or 12-ft. piece of conduit pipe in such a manner that the top of the mantle over the light bulb is parallel with the conduit pipe. The pipe is graduated in inches, with zero located on a line with the top of the light mantle. The distance from the top of the sand bed of the filter to some bench mark, such as the top of the floor over the filter, must be determined, and also the thickness of the sand bed in inches. To make the test, the wash water is turned on and, after the excess turbidity has been washed out, the light is submerged in the filter. The sand bed is expanded while washing and offers no resistance to the light fixture as it is submerged in it. When the light is submerged till the top of the sand bed is even with the top of the light mantle, the sand will settle on the mantle and obstruct the light rays. The operator will find this line to be very sharp, and will have no difficulty in locating it within 1 in. The difference in inches between the distance from the sand bed and bench mark, and the top of the light mantle and bench mark, equals the sand bed expansion in inches.

The temperature of the wash water has a remarkable effect on its viscosity or lighting properties, and it has been conclusively shown, where the temperature of the wash water varies over a wide range, a given rate of wash cannot be correct at all times. At Kansas City we have 27 in. of sand and a 24-in. free board between the top of the sand bed and the lip of the wash water trough. We have found that a wash expansion of from 40 per cent to 45 per cent keeps our sand bed in excellent condition. Due to the elevation of our wash tanks and the size of our wash water lines, a 24-in. vertical rise is the greatest velocity of filter wash possible at our plant. During the past summer, when maximum wash water temperatures were encountered, a sand bed expansion of from 32 per cent to 38 per cent was the greatest we could obtain. This fact was reflected in the condition of our sand beds, as follows: A gradual accumulation of small mud balls appeared over the entire surface of the filter beds. Hard or caked spots progressively increased in number and size. Bacterial efficiency remained about constant. As the wash water temperature decreased in the fall, the sand bed expansion gradually increased with the same rate of wash. With the wash water temperature of 82° F., it was found that a wash rate of 24-in. rise gave a sand bed expansion of only 33 per cent, whereas, with wash water temperature of 33° F., the same 24-in. rise rate expanded the same sand bed 53 per cent. With our present wash water tanks and piping, we have found the critical wash water temperature to be approximately 70° F., that is, we are unable to get a 40 per cent sand bed expansion when wash water temperature is above 70° F.

When the sand bed expansion tests were started at the Kansas City, Mo., plant, the writer felt sure a saving in wash water could be accomplished by reducing the rate of wash as the temperature of the wash water decreased. This assumption, however, has not been substantiated. From a number of tests made during the last two months, it has been quite plainly demonstrated



Instrument for Measuring Filter Bed Expansion

that no wash water economy has been accomplished by holding the sand bed expansion to between 40 per cent and 45 per cent by reducing the rate of wash. The amount of wash water used remains approximately the same, and the only result observed is a shortening or lengthening in the time of wash. We have been unable to demonstrate that the condition of the sand bed is any better under a 55 per cent expansion than it is under a 45 per cent expansion. We have, however, demonstrated, at least to our own satisfaction, that at least a 40 per cent expansion is absolutely essential in our plant to keep the sand bed free from mud balls, shrinkage and hard spots, and in periods of high wash water temperatures we have endeavored to compensate for this deficiency by frequent raking of the sand bed. By this method, we have been able to maintain our filter beds in a fairly satisfactory condition during the summer months, but the results obtained are not really comparable with the results obtained with a 40 per cent to a 45 per cent expansion.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 9th annual Water Works School at the University of Kansas.

Fifth Annual Conference Pennsylvania Sewage Works Association

The Fifth Annual Conference of the Pennsylvania Sewage Works Association was held at the Pennsylvania State College, State College, Pa., on Tuesday and Wednesday, June 23 and 24, 1931. The total registration of members and guests was 123, the membership of the Association at the time of the Conference being 130. The men were housed in two modern dormitories of the college—an arrangement which added much to the comfort and good fellowship of those attending the Conference.

The Tuesday morning session was opened with an address of welcome on behalf of the college by Prof. Elton D. Walker, Head, Department of Civil Engineering, who extended the freedom of the college to the members and their guests. Prof. Walker was followed by Frank E. Daniels, Chief, Industrial Waste Division, Pennsylvania Department of Health, Harrisburg, who presented a paper entitled "The Practical Operation of Sewage Disposal Plant Units." This paper contained valuable advice concerning operating procedure by an engineer of long experience in this work. The last paper of the morning session by Harry Krum, City Chemist, Allentown, Pa., described the new Imhoff tank-sprinkling filter sewage treatment plant now being completed at Allentown, replacing the Landreth Direct Oxidation Electrolytic System which was installed in 1921.

The afternoon session was devoted to sewer maintenance and operation. The first paper by Albert H. Mainwaring, Assistant Engineer, Bureau of Highways, Philadelphia, Pa., described the organization and method of operation of sewer maintenance work in Philadelphia. The same subject, but applying to smaller cities, was covered by Roy L. Phillips, City Engineer, Meadville, Pa.

C. F. Wertz of Fuller & McClintock, Engineers, Philadelphia, Pa., described simple tests which can be made by non-technical sewage treatment operators to give the information necessary for the intelligent operation of their plants and at the same time provide valuable data for future design purposes.

H. M. Freeburn, District Engineer, Pennsylvania Department of Health, Philadelphia, Pa., presented a paper entitled "Admission of Industrial Wastes into Sewer Systems." He presented a very sane general classification of industrial wastes based upon their admissibility into public sewer systems, his paper evoking considerable discussion. The last paper of the afternoon session was presented by Grant M. Olewiler, Assistant Superintendent, Health & Drainage, Lower Merion Township, Montgomery County, on "Sewer Rentals in Pennsylvania." Sewer rentals have been collected since 1905 in Lower Merion Township and his paper ably described the successful methods used by the township.

The Annual Conference Dinner was held Tuesday evening at the Nittany Lion Inn with 105 present. H. E. Moses, Assistant Chief Engineer, Pennsylvania Department of Health, led the Round Table discussion which followed an interesting talk by Prof. E. D. Walker of State College on his observations of unusual sewage treatment practices in southern and western states.

The Wednesday morning session was opened by F. S. Barckhoff, City Engineer, Salem, Ohio, who described the activated-sludge plant at Salem, Ohio. Mr. Barckhoff's experiences would seem to indicate that the activated-sludge type of plant is satisfactory for small cities. John R. Downes, Supervising Engineer, Plainfield-Dunellen, N. J., Sewage Treatment Works, Plainfield, N. J., presented an interesting paper describing the results of experimental work begun in 1925 on the heating of sludge in an earth digestion tank. The last paper of the session, "Effect of Sewage Discharge on Streams," was presented by H. W. Streeter, Sanitary Engineer, U. S. Public Health Service, Cincinnati, Ohio. Mr. Streeter pointed out that the addition of dilution water through tributaries less polluted than the main stream has been observed frequently to result in an increase, rather than a decrease, in the bacterial content of the main stream.

The business meeting of the Conference was held Tuesday morning and at this session the following officers were elected for the coming year:

President, L. W. Monroe, Ellwood City, Pa.; First Vice-President, R. O'Donnell, State College, Pa.; Second Vice-President, Harry Krum, Allentown, Pa.; Editor, J. R. Hoffert, Harrisburg, Pa.; Secretary-Treasurer, L. D. Matter, Kirby Health Center, Wilkes-Barre, Pa.

Messrs. C. A. Emerson, Jr., and H. E. Moses were reappointed as members of the Board of Control of the Federation of Sewage Works Associations.

At the business session appropriate action was taken to amend the Constitution so that the Editor will be included among the officers of the Association.

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Public Water Supplies in Small Ohio Villages

The following table from the *Ohio Health News* shows the number of small villages in Ohio with and without public water supplies:

Population	Number of Villages (Excluding Suburban) With Public Water Supply	Without Public Water Supply
2500 to 2000	21	2
2000 to 1500	32	8
1500 to 1000	51	28
1000 to 500	60	118
Under 500	12	309

The water supply problem in suburban villages is quite different from that in isolated villages and in order to make a fair comparison the suburban villages supplied with water from a larger municipality have been excluded from this list.

From the foregoing table it is apparent that it is very unusual for a village over 1500 in population not to have a public water supply. This table also shows that there are about twice as many villages between 1500 and 1000 in population that have public water works systems as there are villages without such systems, while for villages between 1000 and 500 in population this ratio is reversed. Only the exceptional village under 500 in population has a public water supply.

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WATER MAIN CONSTRUCTION FURNISHES WORK FOR UNEMPLOYED.—The Water Department of Kansas City, Mo., is carrying out a $1,000,000 water main extension program which is providing work for 2000 men in 4-hour daily shifts at 55 ct. per hour.

EDITORIALS

ANNOUNCING THE NEW EDITOR

LINN HARRISON ENSLOW will assume the editor's toga of WATER WORKS AND SEWERAGE commencing with the October issue. He has given a lifetime of service to the field reached by this paper and is exceptionally well-qualified by reason of both his long and varied experience and his wide and popular acquaintance throughout the field to guide the editorial destinies of this paper.

An engineer of achievement and repute, Mr. Enslow brings to WATER WORKS AND SEWERAGE a wealth of talent and ability and his important work in the future will be to interpret the broader plans of development in this field.

The enviable reputation enjoyed by WATER WORKS AND SEWERAGE, not only will be sustained under Mr. Enslow's able guidance, but, we feel sure, will be greatly enhanced. It is entirely fitting that a paper that has been the outstanding publication in this field for many years should attract and bring into close association one of the leaders of the profession. It is with both pardonable pride and a great deal of pleasure that we make this announcement to our readers.

Mr. Enslow was born in Richmond, Virginia, in 1891. He graduated from Virginia Polytechnic Institute, as a Bachelor of Science in chemical engineering and started his career as a chemist with the General Chemical Company. While thus employed he carried on graduate work in chemistry at Johns Hopkins University and in 1915 joined the staff of the Maryland State Department of Health as a chemist.

Here, in collaboration with a former classmate, Abel Wolman, he developed the excess chlorine or "residual chlorine" method of controlling chlorine dosage, a method now in universal use throughout the sanitary field. In 1918 Mr. Enslow became superintendent of the filtration plant in Spartanburg, S. C., and a year later superintendent of the filtration plant at Gatun, Canal Zone, where he was also chemist in charge of the experimental filtration plant at Gatun.

In 1920 he accepted the position of assistant engineer, Virginia State Department of Health and here had supervision over water purification plants and conducted special studies toward improved operating procedure and plant design.

After a half-decade in this connection he became research engineer of the Chlorine Institute, Inc., and while here achieved outstanding successes in the development of new uses of chlorine in sewage treatment. Mr. Enslow will continue to serve the Institute in an advisory capacity. During the latter years of his association with the Institute he has been an associate editor on WATER WORKS AND SEWERAGE.

Mr. Enslow is a member of the American Society of Civil Engineers, the American Institute of Chemical Engineers, the Federation (U. S.) of Sewage Works Associations, the Chemists Club of New York, and the State Sewage Works Associations of New York, California and New Jersey. He holds a fellowship in the American Public Health Association, is Vice Chairman of the Publication Committee of the American Water Works Association, and is an honorary member of the British Association of Sewage Works Managers.

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A Prophet With Honor

A full share of pride must be felt by engineers and chemists who have had a hand in water supply and sewage disposal developments when reviewing certain statements incorporated in a recent report from The Engineering Foundation on the question—"How have engineering sciences added to human happiness?"

A symposium held on this topic by the four major Engineering Societies and their research agency, The Engineering Foundation, results in a composite opinion covering—"a few samples of the many benefits which science, engineering and chemistry have made possible within the last half century" and adds "How came these things to be such commonplaces?"

Is it not enough that in such a report the matter of progress in the perfection of water works and supply is given first ranking and sewerage developments next?

The 1931 Convention of New England Water Works Association

The 50th annual convention of the New England Water Works Association will be held Sept. 29 to Oct. 2 at the Hotel Statler, Boston, Mass. The program of the convention follows:

TUESDAY, SEPTEMBER 29TH

9 a. m. to 10 a. m.—Registration.

10 a. m. to 12 noon—Opening, business meeting and committee reports.

Award of Dexter Brackett Memorial Medal.

12 noon to 2:30 p. m.—Luncheon and welcoming addresses by prominent officials.

2:30 p. m. to 5 p. m.—Historical papers.

a. "History of the New England Water Works Association," by Charles W. Sherman, Consulting Engineer, Boston, Mass.

b. "History of the Boston Water Works," by Frank A. McInnes, Consulting Engineer, Boston, Mass.

c. "Trend of Water Works Practice in Past Fifty Years," by Caleb M. Saville, Manager and Chief Engineer, Water Bureau, Hartford, Conn.

Evening—Reception and dance.

WEDNESDAY, SEPTEMBER 30TH

Superintendents' Day

9 a. m. to 11 a. m.—Presiding Officer, W. A. McKenzie, Superintendent Water Works, Wallingford, Conn.

Subject: "Emergency Problems of the Water Works Superintendent."

Introductory paper: "Chlorination for Special Emergency Purposes," by J. D. MacMahon of the Matheson Alkali Works, Niagara Falls, N. Y.

11 a. m. to 12 noon and 2 p. m. to 3 p. m.—Presiding Officer, H. J. Cook, Superintendent of Water Works, Auburn, Maine.

Subject: "Tuberculation of Mains and Services."

Introductory paper: "Tuberculation of Mains as Affected by Bacteria," by H. G. Reddick and S. E. Linderman, United States Pipe and Foundry Co., Burlington, N. J.

3 p. m. to 5 p. m.—Presiding Officer, S. H. Taylor, Superintendent of Water Works, New Bedford, Mass.

Subject: "Relation of Water Works to Fire Fighting."

Introductory paper: "Fire Flows at Conflagrations," by C. W. Mowry, Factory Mutual Fire Insurance Cos.

5 p. m. to 6 p. m.—Demonstration of the Boston High Service Fire Fighting System, courtesy Fire Commissioner Edward F. McLaughlin.

Afternoon—Bridge party for the ladies.

Evening—Smoker.

THURSDAY, OCTOBER 1ST

9 a. m. to 12 noon—Symposium on Water Purification in New England.

a. Preliminary paper by R. S. Weston, Consulting Engineer.

b. "Operating Experiences at Filter Plant, Cambridge, Mass.," by Professor M. C. Whipple.

c. "Purification Problems at Providence," by E. L. Bean.

d. "Water Filtration at Hartford," by W. A. Gentner.

e. "Operation of the Greenwich Filter Plant," by H. C. Chandler.

2 p. m. to 5 p. m.—General subject: "The Allocation of Interstate Waters for Water Supply Purposes."

a. "The Law of Interstate Waters and its Application in the Case of the Delaware River," by Thaddeus Merriman, Chief Engineer, Board of Water Supply, New York City.

b. "The Case of Connecticut vs. Massachusetts Over the Diversion of Waters from the Swift and Ware Rivers," by Frank E. Winsor, Chief Engineer, Metropolitan District Water Supply Commission, Boston.

Discussion of these papers will be presented by H. T. Critchlow, Harrison P. Eddy, George W. Fuller, Charles E. Ryder, Morris R. Sherrerd, W. L. Stevenson, J. Waldo Smith, Solomon Swaab.

7 p. m. to 8 p. m.—Banquet.

8 p. m. to 9 p. m.

a. Report of tellers upon election of officers for ensuing year.

b. Presidential address.

c. Address by Col. Charles R. Gow.

9 p. m.—Dancing.

FRIDAY, OCTOBER 2ND

Excursion over Metropolitan Water Works system, visiting Chestnut Hill pumping stations and Sudbury and Wachusett Reservoirs.

Luncheon en route.

COMING CONVENTIONS

NEW YORK SECTION, A. W. W. A.—Convention at Niagara Falls, N. Y., Sept. 22-23. E. D. Case, The Pitometer Co., 50 Church St., New York, N. Y., is secretary.

INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS.—The annual conference of this association will be held Sept. 24, 25 and 26, at the Pennsylvania Hotel, New York, N. Y.

AMERICAN ASSOCIATION OF ENGINEERS.—The 1931 convention will be held Sept. 28, 29 and 30, at Huntington, W. Va. M. E. McIver, secretary, 8 South Michigan Ave., Chicago, Ill.

NEW ENGLAND WATER WORKS ASSOCIATION.—Annual convention, Sept. 29-Oct. 2, Hotel Statler, Boston, Mass. Program is given elsewhere in this issue.

INTERNATIONAL CITY MANAGERS ASSOCIATION.—Annual meeting, Oct. 7-10, at Louisville, Ky.

CENTRAL STATES SECTION, A. W. W. A.—Annual convention, Starrett's Netherland-Plaza Hotel, Cincinnati, O., Oct. 8-9. B. J. Lechner, secretary-treasurer, Commissioners of Water Works, Erie, Pa., is secretary-treasurer of the section.

SOUTHWEST WATER WORKS ASSOCIATION.—Annual convention, Jung Hotel, New Orleans, La., Oct. 19-22. Lewis A. Quigley, superintendent, water works, Fort Worth, Tex., is secretary-treasurer.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Annual meeting, Oct. 19-26, at Pittsburgh, Pa.

ROCKY MOUNTAIN SECTION, A. W. W. A.—Fifth annual convention, Oct. 21-23, Denver, Colo. Dana E. Kepner, 226 Continental Oil Bldg., Denver, Colo., is secretary-treasurer.

PENNSYLVANIA WATER WORKS ASSOCIATION.—The 36th annual convention will be held at Atlantic City, N. J., Oct. 21, 22 and 23. F. S. Purviance, Room 327 Telegraph Bldg., Harrisburg, Pa., is secretary.

WISCONSIN SECTION, A. W. W. A.—Convention at Hotel Racine, Racine, Wis., Oct. 26-27. L. A. Smith, Superintendent Water Works, Racine, is secretary.

CALIFORNIA SECTION, A. W. W. A.—Convention at Stockton, Calif., Oct. 28-31. E. W. Green, San Jose Water Works, 374 West Santa Clara St., San Jose, Calif., is secretary.

MISSOURI VALLEY SECTION, A. W. W. A.—Annual convention at Eldridge Hotel, Lawrence, Kan., Oct. 29-31. Earl L. Waterman, professor of sanitary engineering, University of Iowa, Iowa City, Ia., is secretary-treasurer.

MINNESOTA SECTION, A. W. W. A.—Convention at Hotel Lowry, St. Paul, Minn., Oct. 30. R. M. Finch, Wallace & Tiernan Co., Inc., 614 Flour Exchange Bldg., Minneapolis, Minn., is secretary.

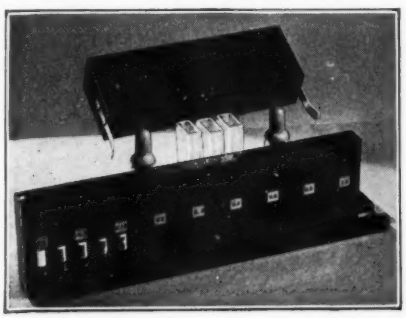
NORTH CAROLINA SECTION, A. W. W. A.—Convention at Greensboro, N. C., Nov. 2-4. H. G. Baity, Professor of Sanitary and Municipal Engineering, University of North Carolina, Chapel Hill, N. C., is secretary.

NATIONAL MUNICIPAL LEAGUE.—Annual meeting, Nov. 9-11, at Buffalo, N. Y.

NEW EQUIPMENT AND MATERIALS

New Chlorine Comparators

W. A. Taylor & Co., 872 Linden Ave., Baltimore, Md., has developed and recently placed on the market the Enslow slide chlorimeter, Taylor swimming pool set, and combination swimming pool set, for control of chlorine and pH in water, sewage, industrial wastes, swimming pools, etc. All this equipment is molded



Enslow Slide Chlorimeter

from Bakelite and works on the slide principle, thus combining durability, precision, convenience and simplicity.

All these sets are similar in construction and method of operation. Each consists of two principal parts—the slide and the base, as shown in the illustration. The slide is a Bakelite case 10 by 2.75 by 6.25 in. It contains nine color standards representing different amounts of chlorine or pH values, and eight ampoules of distilled water, the ampoules of water alternating with the color standards. The lower part of the base contains a slot in which the slide may be moved back and forth, two holes containing vials of ortho tolidine or phenol red solution, or both, and three holes containing molded Pyrex cells 89 by 25 by 11 mm. The upper half of the base serves as a cover for the vials and cells when the set is not in use and is fastened to the lower part by means of spring catches.

The Enslow slide chlorimeter, shown above, contains nine chlorine standards representing 0.0, 0.1, 0.15, 0.2, 0.3, 0.4, 0.6, 0.8, 1.0 p.p.m. of chlorine. A determination consists of only three simple operations: (1) The three cells are filled to the mark (11.5cc) with the sample to be tested and placed in the three holes in the base. (2) To the central cell 0.5cc of ortho tolidine solution is added and the contents thoroughly mixed. (3) The slide containing the chlorine standards is placed in position on the base and is moved back and forth in front of the test sample until a color match is obtained. The chlorine content is then read directly from the values on the front of slide.

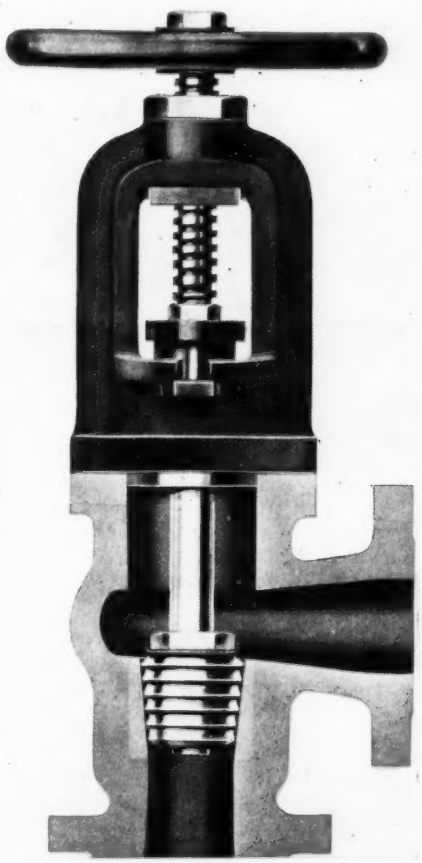
The Taylor swimming pool set is similar in all respects to the Enslow slide chlorimeter except that the slide is divided into two sections. The left section contains five phenol red color standards (6.8, 7.2, 7.6, 8.0, 8.4) for pH determinations, and the right section four chlorine standards (0.0, 0.2, 0.5, 0.8 p.p.m.) for chlorine determinations. The base contains one vial each of ortho tolidine and phenol red solution.

Combination swimming pool set consists of one complete Enslow slide chlorimeter and an additional slide containing nine phenol red color standards (pH 6.8, 7.0, 7.2, 7.4, 7.6, 7.8, 8.0, 8.2, 8.4). This set allows more precise control of both chlorine and pH than is obtained with the single slide set.

Each of these sets is supplied in a polished wooden case 11 by 3.75 by 4.75 in., with a handle for carrying. The case serves not only to keep all the equipment together in portable form but also to protect the sets from dust and dirt when not in use.

Ludlow Announces New Valve

A new valve providing multi-step reduction of velocity and density across the valve seat has been announced by the Ludlow Valve Manufacturing Co., Troy, N. Y.



Ludlow Multi-Valve

The heart of this Ludlow multi-valve is the multi-stage plug or cone. This cone is corrugated with specially curved grooves in the side, forming a number of contact lands that seat against the converging wall of the outlet, as shown in the cross section.

These grooves form annular expansion chambers, the area of each increasing with the circumference of the cone, thus reducing the density of the fluid step by step and forming separate back-pressure pockets which retard the flow.

The stainless steel cone swivels on the stainless steel stem. As long as its beaded lands are in contact with the converging walls of the seat, the cone cannot revolve, but once free from the seat it rotates with the spindle. In this way the cone continually corrects any possible leakage by presenting a new sealing surface for contact with each successive seating.

Boring Tool for Installing Pipe

Development of an improved tool that permits boring under a street without in-

Hydrauger Boring Under City Pavement

terference of traffic, is announced by the Hydrauger Corporation. It is a compact unit driven by compressed air and connected with running water. The unit is comprised of an auger which can be placed in a trench. The compressed air operates the auger and the circulation of water washes the borings back as fast as they are cut. The feed ahead is accomplished by a simple reversible ratchet. As boring of the hole is completed to its desired diameter, the permanent pipe can be pushed in either by hand or by the aid of the ratchet on the Hydrauger.

The Hydrauger is made in two sizes—2½ in. and 5 in.—and with use of a reamer attachment the size of hole can be approximately doubled. Maximum boring speed in feet per minute, including insertion of boring-bar lengths is ½ to 2 ft. Air pressure of 85 lb. is required and

the consumption of air per cubic feet per minute for the 2½-in. size is 54 lb. and for the 5-in. size is 80 lb. The desirable water pressure in pounds per square inch ranges from 75 to 100 cu. ft. and much less pressure can be used satisfactorily.

The length of the smaller machine is 7 ft. 3 in. and of the larger machine 10 ft. 3 in.; and the weight of the 2½-in. machine is 260 lb. while the 5-in. machine is 410 lb.

The manufacturers report that the Hydrauger may be used for all types of excavation for pipe and conduits under streets and roadways and also for special excavating where it is impracticable to dig an open trench.

The manufacturers have prepared literature describing the machine in detail and copies may be obtained by addressing the Hydrauger Corporation, 1298 Bryant St., San Francisco.

New Red Band Adjustable Shaft Motor

A new adjustable shaft motor has been brought out by the Howell Electric Motors Co., Howell, Mich. The adjustment of the shaft is accomplished by cast steel housing, accurately machined with 16 threads per inch. One of the outstanding advantages claimed for this type of motor construction is that all adjustments can be made while the motor is in operation, carrying its full load at full speed. It is stated that by placing a wrench on the micrometer adjustment, a "gallon per minute meter" on the pump and an amperementer on the motor, it can be adjusted to maximum capacity of the pump at maximum efficiency of the motor per horsepower in not more than five minutes, with the motor in operation.

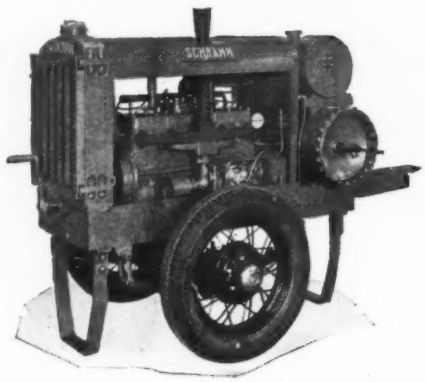
Motor with Protecting Head in Place

The lubrication chamber of the adjustable shaft motor is totally enclosed at all times while adjustments are being made. This prevents the possibility of injurious materials entering the housing or the ball bearings. The assembly is entirely separate from the protecting hood.

This new adjustable shaft feature is obtainable for vertical or horizontal motors, constant or multi-speed motors, and single phase or polyphase motors. This feature is built into the standard line of Red Band motors.

A New Small Size Compressor

An addition to its line of portable gasoline driven compressors has been announced by Schramm, Inc., West Chester, Pa. This is a 36 cu. ft. unit containing many of the features found in the larger models. It is a heavy duty 6-cylinder outfit, with four power and two air cylinders, the two cylinders in the center supplying air and the four outside cylinders furnishing the power. The automatic governing features, slowdown device, high tension magneto, carburetor, air filter, water circulating pump, fan, steel housing with removable sliding doors, large single core, or sectional radiator, are the same features used in the larger units. The crankshaft, which is of exceptionally large diameter, has seven main bearings.



New Schramm Compressor

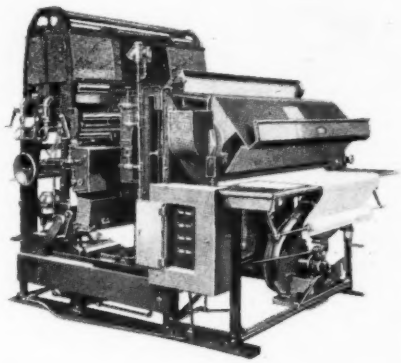
Any of the various mountings, including the two wheel trailer equipped with pneumatic tires, can be furnished on this new size. Write Schramm, Inc., West Chester, Pa., for their bulletin 3101 describing the new 36 cu. ft. unit.

Continuous Blue-Printing Equipment Developed by Pease

The new Pease "Peerless" Model "25" continuous blue-printing equipment is intermediately priced between the Pease "Peerless" Model "30" and Model "20" blue-printing machines and combines many of the outstanding features of both. Model "25" was particularly designed to meet both the demands of the moderate budget for blue-printing equipment and the requirements for high quality prints at the same time.

The Model "25" complete equipment is composed of three units: the blue-printing machine, the washing machine, and the potashing, washing, and drying machine.

The blue-printing machine can be operated independently from the washing, potashing, and drying equipment by means of a simple clutch adjustment. All units are made in two sizes, 42 in. and 54 in. wide and the machines can be wired to operate on either 220 volts direct or alternating current. The 42-in. machine is equipped with 6 lamps and the 54-in. machine with 7 lamps.

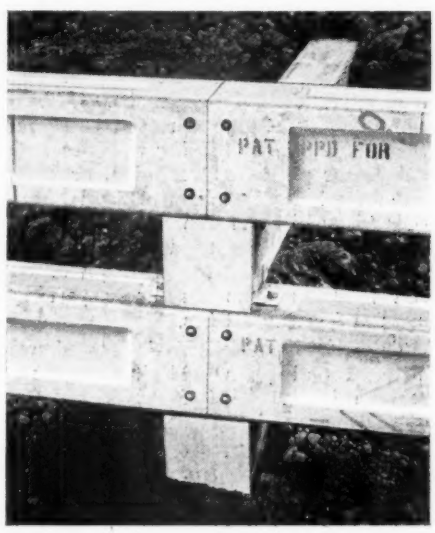


Pease Model "25" Blue Printing Machine

The dryer of the Model "25" is something entirely new in arrangement. It is a twin-radiator air-type dryer consisting of two banks of heating units between which the paper travels, around a floating idler roll that can be raised or lowered by means of a crank handle, thus making it easy to thread the paper through the machine.

Armco Introduces Metal Cribbing

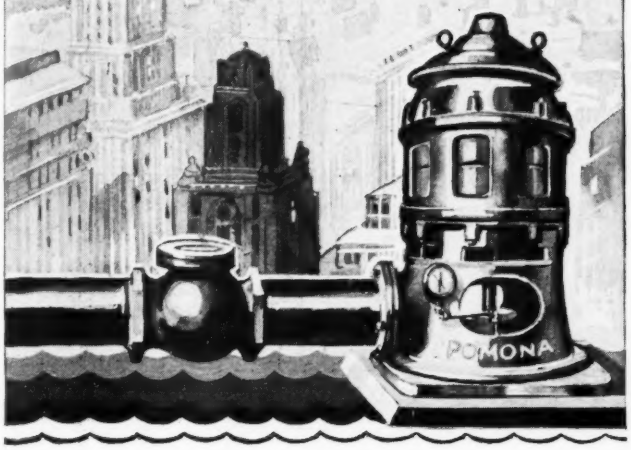
A booklet describing a new metal cribbing (developed recently by the American Rolling Mill Company) of simple, yet effective design is being offered by the Armco Culvert Mfrs. Association, Middletown, Ohio. The new cribbing is adaptable to use for railroad and highway retaining walls, bridge wing walls and river and harbor bank protection work.



Open Face Style Armco Metal Cribbing

Drawings and photographs show how the cribbing is installed and how both the open and closed-face types look when in place. A copy will be sent on request.

The Trend is toward Water Lubricated PUMPS



A study of various types of deep well pumps, on the part of waterworks engineers, leads to one logical conclusion—WATER LUBRICATION is the essential factor. So pronounced is the trend toward water lubrication that many health commissioners are insistent upon the selection of pumping equipment that does not require oil below the surface. Pomona Turbine Pumps built their reputation principally upon the elimination of oil lubrication. Years ago water lubrication was a revolutionary idea. Many engineers were skeptical. But today thousands of Pomona Pumps testify to the merit of such a principle and the same engineers are fully in accord with the idea.

Pomona is now selling more turbine pumps than any other manufacturer in the country. Oil-free Goodrich cutless bearings; built-in Westinghouse motors; open-bottom variable capacity impellers; simplicity of design and high efficiency are some of the reasons that have won this popularity.

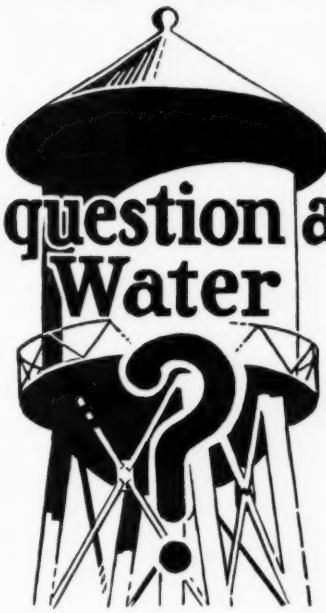
Pomona Pump Co., Pomona, Calif.

POMONA

WATER LUBRICATED

TURBINE PUMPS

PITTSBURGH DES MOINES



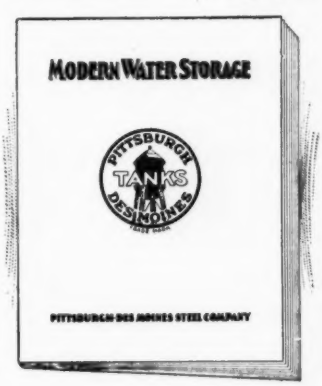
Any question about Water

"Pittsburgh-Des Moines" has been supplying American municipalities with modern water systems, including the latest improved equipment and accessories, for over 38 years. Write or wire our nearest office for a proposal to take care of your particular water supply problem.

QUALITY PITTSBURGH TANKS DES MOINES **TANKS**

Just Off the Press— Write for Your Copy!

"Modern Water Storage," our new 28 page catalog in convenient file size, is now ready for interested municipal and industrial officials—or others contemplating the installation of an up-to-date water system. It gives reliable information, interesting photographs, and authentic engineering data and specifications on the various types of "Pittsburgh-Des Moines" elevated tanks, standpipes, steel reservoirs, treating plants, and complete water systems. Our nearest office will cheerfully supply your copy.



Pittsburgh-Des Moines Steel Company

3418 Neville Island, Pittsburgh, Pa.
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New York Chicago Dallas Atlanta
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WITH THE MANUFACTURERS

Stevenson, Sanitary Engineer, Joins Great Western Electro-Chemical Co.

Ralph A. Stevenson, for the past four years superintendent of the Sacramento Filtration Plant, has joined the research and engineering staff of Great Western Electro-Chemical Company of San Francisco and Pittsburg, Calif., as the company's expert consultant on water purification, sewage disposal, and municipal sanitation.

Ralph A. Stevenson

Stevenson is well known to sanitation men throughout the West. He served as chemist and bacteriologist at the Sacramento Plant from 1923 until his appointment as superintendent. He is a past president and member of the Sacramento Chapter of the American Chemical Society, a past director and member of the Sacramento Chapter of the American Association of Engineers, a member of the American Water Works Association and the California Sewage Works Association. He received his training at the University of Chicago, where he entered after service in the war, as a student in Sanitary Sciences.

During his stay in Sacramento, Stevenson built up a considerable consulting practice in Northern California, and has done extensive research work in the use of chlorine in the sanitary field.

Ludlow Valve Mfg. Co. to Manufacture in Canada

The Ludlow Valve Mfg. Co. of Troy, N. Y., makers of the Ludlow "Diamond" Hydrants, Double Gate Valves, and the Ludlow Multi-Valves, will manufacture in Canada as The Canadian Ludlow Valve Mfg. Co., Limited. Offices are located at 930 Wellington St., Montreal, Que., and factories at Three Rivers, Que., St. Thomas, Ont., and Fort William, Ont. The company states that, in manufacturing Ludlow valves and hydrants in Canada, great care will be taken to ensure the maintenance of the high quality and workmanship which have always been associated with the name Ludlow. The patterns used are from the original models, and only the most experienced workmen are employed. All work is carried out under the supervision of Ludlow trained engineers, and every hydrant and valve is hydrostatically tested and examined before shipment.

Worthington Pump and Machinery Corporation Announces Appointments to Its Staff

During the past few weeks, several important additions have been made to the staff of the Worthington Pump and Machinery Corporation, 2 Park Ave., New York, N. Y. At the same time, certain organization changes also were announced. Otto Nonnenbruch, for the past four years chief engineer of the Diesel department of I. P. Morris and De La Vergne, Inc., Philadelphia, Pa., and prior to that with Worthington in various capacities for nine years, rejoined the latter organization as of July 1. Mr. Nonnenbruch will make his headquarters at Buffalo, N. Y., as special sales representative. J. B. Allen, formerly president of the Allen Engineering Company, Bridgeport, Conn., and prior to that time with the Sperry Gyroscope Company, Brooklyn, N. Y., has been appointed special marine representative with headquarters at Harrison, N. J. H. G. Wood, formerly assistant manager of the New England division of the Westinghouse Engineering and Manufacturing Company, has joined the Worthington organization in the capacity of electrical sales engineer. E. M. Paulin, Jr., has been appointed electrical sales engineer at the Cincinnati, O., works of the Worthington Corporation. Mr. Paullin was associated with the New York office of the General Electric Company as synchronous motor specialist. John T. Clancy, assistant manager, Buffalo Works sales division, has transferred his headquarters from Buffalo to Harrison, N. J. E. W. Hammond, formerly located at Buffalo, has been transferred to Los Angeles as special representative of Diesel and gas engine sales on the Pacific Coast. A. M. Boehm goes to Kansas City as Diesel and gas engine specialist. He formerly was in the Sales department at Buffalo Works.

Joseph F. Hecking, formerly with the Diesel engine sales division in New York, has been assigned to the Diesel and gas engine sales division at Buffalo. William J. Daly, assistant manager, Cincinnati Works sales division, has been assigned to Pittsburgh, Pa., on special sales work. G. A. Herrmann, formerly sales engineer at Chicago has been appointed acting district manager at St. Paul. W. R. Kennedy, sales engineer at Pittsburgh, has been appointed acting district manager at Kansas City.

Bruton Appointed District Sales Manager for American Manganese Steel Co.

W. C. Bruton, for many years an Amsco Sales Engineer working from the Oakland, Calif., office, has been appointed District Sales Manager for the Pacific Northwest Territory comprising Oregon, Washington, British Columbia and the Coeur D'Alene district in Idaho. Working with Mr. Bruton in the sale of Amsco products are agency representatives, P. R. Hines, Lewis Building, Portland, Ore., and Paragon Supplies, Ltd., 845 Hastings St. East Vancouver, B. C., Canada, who have been connected with this company for years. The Seattle office is located at 411 Colman Bldg.

Sullivan Machinery Co. Has New Boston Office

Sullivan Machinery Co. announces the removal of its New England sales office from 45 Milk St. to 100-102 Brookline Ave., Boston, Mass. In connection with this new location, ample warehouse facilities will be provided for carrying Sullivan compressors, drills, and spares in stock for prompt service to New England and Maritime Province customers. Edwin T. Hall is manager of the New England sales office.

Earl Bremer of Chicago Gets Westinghouse Advancement

Earl B. Bremer, who has been located for 13 years in the Chicago office of the Westinghouse Electric and Manufacturing Co., recently as manager of small motors section, has been appointed manager appliance electrification with headquarters at East Springfield, Mass., according to a statement by Fred T. Whiting, northwestern district manager.

WATER WORKS AND SEWERAGE

OCT. 1931

VOL. 78 No. 10

A GILLETTE PUBLICATION

NOVEL SEWAGE TREATMENT PROCESS DEVELOPED FOR DEARBORN, MICH.

By MARK B. OWEN

Commissioner of Public Works and Engineering, Dearborn, Mich.

Mark B. Owen, Commissioner of Public Works and Engineering, Dearborn, Mich.

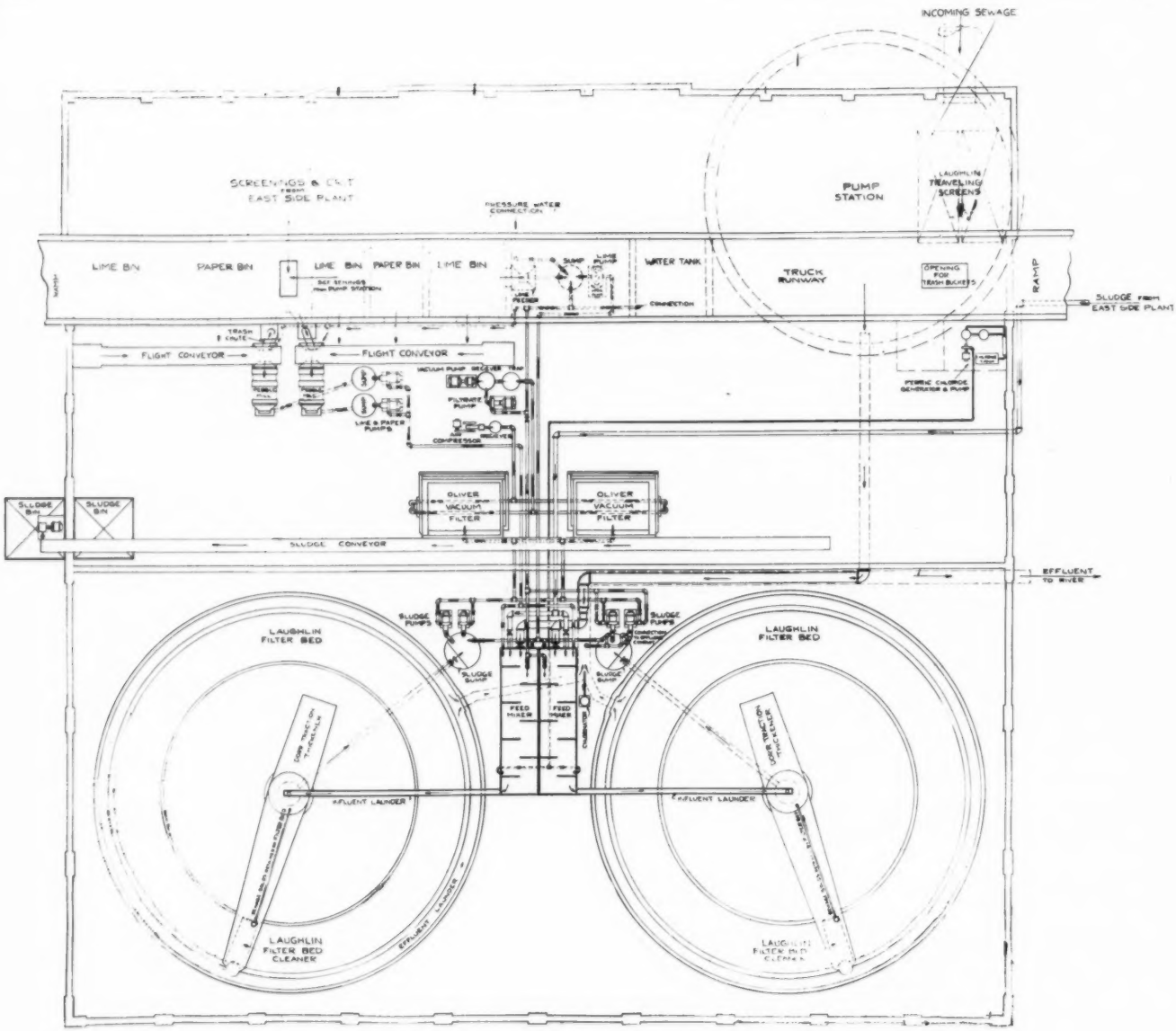
THE present city of Dearborn was formed in 1928 by the consolidation of the former cities of Dearborn and Fordson and a portion of Dearborn Township. Geographically it is located on the western limits of Detroit and is partially bounded by Detroit on the north, south and east. It is traversed by the River Rouge.

In 1924 the former city of Fordson put in operation a sewage treatment plant composed of grit chambers and Imhoff tanks designed to treat an average daily flow of about 5 million gallons. This is now called the East Side Plant.

During 1926, when the city of Detroit had under construction the existing Southfield Road sewer, that runs through the present city of Dearborn, easements were required from the Ford Motor Company to obtain an immediate outlet into the River Rouge and to ultimately continue the sewer to the Detroit River. This sewer drains an area of about 40 square miles. Before obtaining these easements an agreement was entered into by the former city of Dearborn and Detroit for a combined temporary sewage treatment plant. Because of an existing Michigan statute it was deemed advisable for Dearborn to finance, build, operate and maintain the plant. In turn Detroit was to supply the plans for the project and was to pay its prorated cost of the expense of operation to Dearborn. The old city of Dearborn had already provided, by bond issue, about $200,000 for their portion of the cost, but before plans could be provided and construction started the amalgamation of the two cities, Fordson and Dearborn, was affected and all plans were temporarily stopped.

The present city of Dearborn took up the problem anew in 1929. Plans were presented by Detroit's engineers which provided an activated sludge plant requiring 40 acres of land and the estimated cost exclusive of engineering and land was $800,000. It was obviously impossible for Dearborn to consider any such expenditure and as a result the writer was ordered to inspect and investigate other means and ways of treating sewage, and during 1930 an experimental sewage treatment plant was built under the joint direction of W. C. Laughlin of the Filtration Equipment Corporation and the Superintendent of Public Works and Engineering of Dearborn.

Experimental Plant and Process Development.—The experimental plant was constructed on a part of the site of the old Fordson Disposal Works. A steel building 40 ft. by 60 ft. by 24 ft. high was erected and all activities except laboratory work were confined therein. The sewage tank or clarifier, was constructed of fir lumber 30 ft. by 12 ft. by 12 ft. on adequate concrete foundations. It provided for a detention period of 1½ hours, with a flow of ½ m.g.d. or 3 hours with ¼ m.g.d. A 350 gal/min. Jennings self-priming sewage pump with



Layout of the West Side Sewage Disposal Plant of the City of Dearborn, Mich.

intake between existing grit chambers and Imhoff tanks delivered raw sewage to the clarifier. The flow was recorded by a Republic recording meter. Two small wooden tanks about 5 ft. square and 8 ft. high were built to use as mixing tanks for chemicals and paper pulp. A Paradon chlorinator was installed at the effluent end of the clarification tank. A small rotary vacuum filter was installed to dewater the sludge.

About 600 lb. of lime, 200 lb. of ferric chloride and 300 lb. of paper, as pulp, were added to, and mixed with, the incoming raw sewage. Upon settling, the liquid was discharged upward through trays containing crushed magnetite which served as a filter, or scrubber to remove the light residual suspended matter resisting sedimentation.

The filtering process held back the lighter particles and colloidal material that otherwise would pass out as suspended particles in the effluent. Regular back washing of these filters is required and the frequency of such cleansing was found to vary with the sewage flow and volume of solids contained therein. The filter discharge was treated with chlorine and allowed to discharge into the river.

Solids deposited in the clarifier are withdrawn as a sludge containing about 97 per cent water and delivered to a rotary vacuum filter where the moisture content is reduced to as low as 60 per cent. In this condition no odor is present and no appreciable deterioration of the dry cake has been noted within at least a year.

Pulp was obtained by using the waste paper collected by the city and grinding same in a hammermill. Water for this purpose was the liquor from settled sewage. Lime supplied in sacks was used to prepare a milk of lime solution to feed into sewage. This solution with paper pulp was piped, from small wooden tanks to the suction side of pump delivering sewage to clarifier. Ferric chloride solution, containing 47 per cent $Fe\ Cl_3$, was furnished by the Pennsylvania Salt Company in carboys. This chemical was applied to the sewage from twenty gallon crocks placed above the clarifier at the influent end.

At the discharge end of clarifier the liquid was chlorinated. Although it was not possible to apply this chlorine as perfectly as would be desired, the results obtained were generally very good. It is thought that under normal conditions, the results from chlorination in this process will be excellent and probably above the average results obtained from chlorination in conjunction with other known processes.

Character of Sewage Treated and Results Secured.—The sewage treated represented about 1 per cent of the dry weather flow from a population of approximately

TABLE I—ANALYSES OF RAW SEWAGE EFFLUENT

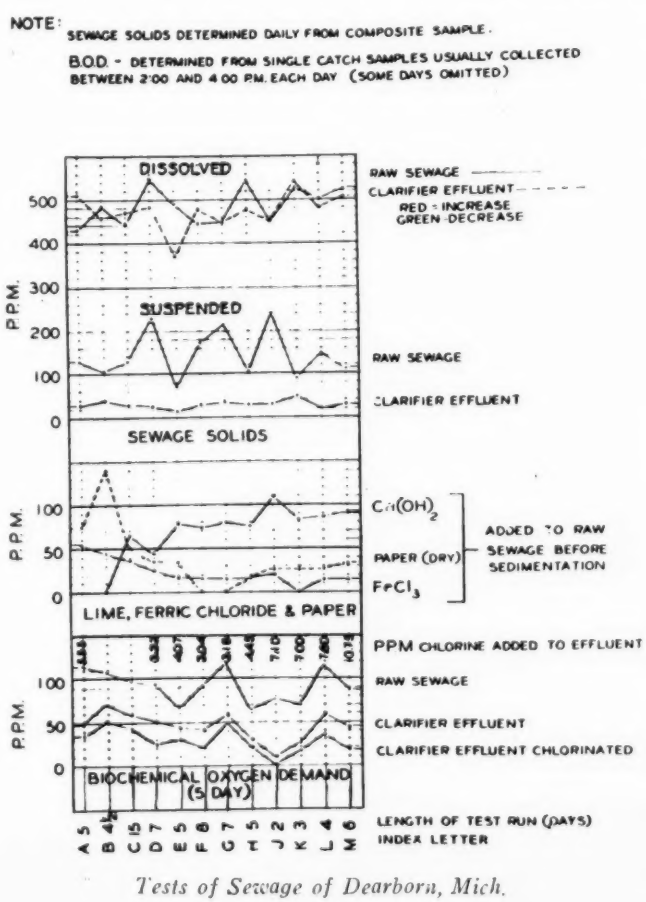
	Influent			Effluent			Chlor. Eff.			Red.
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Per cent
SOLIDS										
Total	1550	440	639	790	210	494	....	..	....	23
Suspended	920	45	175	70	10	26	....	..	....	86
NITROGEN										
Ammonia	32	6	15	28	6	14	....	..	....	....
Organic	4.8	0.8	2.9	3.6	0.4	1.5	....	..	....	....
CLORIDE	78	28	56	180	44	81	....	..	....	....
pH	8.4	7.0	7.3	8.4	7.0	7.8	....	..	....	....
ALKALINITY	700	70	336	820	140	323	....	..	....	....
DISSOLVED OXYGEN	5.3	0	1.1	9.8	3.5	6.9	....	..	....	....
B.O.D. 5 day	250	15	100	210	3	55	67	5	33	67
RELATIVE STABILITY										
Days	.....	.....	.....	10	0.5	3.1	10	1	8.0	....

146,000 people. It is a normal sewage containing from 60 to 220 p.p.m. suspended solids and 430 to 550 p.p.m. dissolved solids. The B.O.D. ranged from 60 to 140 p.p.m.

Samples of raw sewage and treated sewage were collected hourly, was composited over 24 hours, and regular standard analyses made. Table I covers analyses of raw sewage and effluent over a period of approximately ten weeks. Standard Methods of the American Public Health Association for analysis of sewage were used.

Hubbell, Hartgering and Roth, consulting engineers, were retained to review and report upon the results of the experimental work. A report was submitted which included the chart accompanying this article. In this review Mr. Hubbell said, "Attention is particularly invited to the chart which shows very clearly the character of the sewage treated, the suspended solids removed by chemical precipitation, and the reduction in biochemical oxygen demand by chemical precipitation and by the addition of chlorine to the effluent.

"The chart also indicates the amounts of lime, ferric



Tests of Sewage of Dearborn, Mich.

chloride and paper added to the raw sewage before sedimentation. From a study of this chart, it would appear that the proportion of paper added does not much affect the removal of suspended solids nor of biochemical oxygen demand. The excessive amount of paper used in test 'B' appears, if anything, to have increased the suspended solids in the clarifier effluent over what they would have been without the use of paper. The biochemical oxygen demand also shows an increase in this test.* In general, the biochemical oxygen demand appears to decrease with an increase in the use of lime.

"The efficiency of ferric chloride in assisting sedimentation was indicated by the increase in suspended solids in the clarifier effluent in test 'K' in which ferric chloride was omitted. Chlorine added in amounts as low as three to five parts per million appear to be very efficient. This is due to the very clear character of the effluent. For Imhoff tank effluents some ten to twelve parts per million would be required to accomplish equal sterilization."

Table II is a comparison of the results of our Imhoff tanks with the experimental tank as far as solids removal is concerned.

"It will be noted that the amount of sludge obtained by chemical precipitation is about three times that obtained by plain sedimentation. This is due to more complete removal of suspended solids, and to the addition of solids in the chemicals used."

New West Side Plant Under Construction.—In designing the new plant it was contemplated to treat sewage from about 12 square miles of Dearborn, and the sludge from sewage of 33 square miles of Detroit territory, and all sludge from the existing Dearborn East Side plant serving approximately 12 square miles of Dearborn.

It is proposed to convert the Imhoff tanks at the East Side plant to plain sedimentation tanks and pump 97 per cent sludge daily to the new plant through an 8-in. pipe line. Grit and screenings at the old plant will be trucked to the new plant and disposed of as described below.

The West Side plant, located at Greenfield Avenue and the River Rouge, will be completely enclosed in one structure of early American design.† Plans call for complete heating and ventilating of building. Walls of entrance lobby, laboratory and motor room will be terra

TABLE II—COMPARISON OF RESULTS OF IMHOFF TANKS AND EXPERIMENTAL TANKS

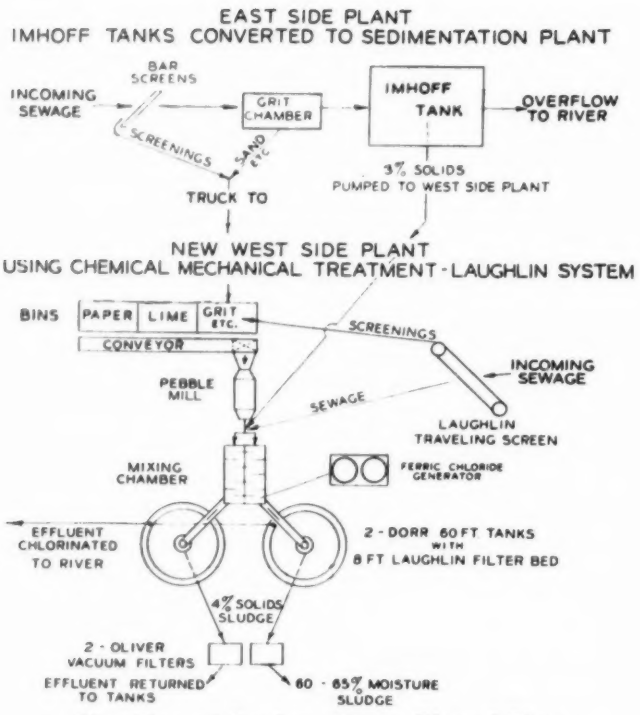
	Raw Sewage	Imhoff Effluent	Exp. Tank Effluent
Total Solids	636	542	496
Per cent reduction		15	22
Suspended Solids	175	96	23
Per cent reduction		45	87
Settleable Solids (c.c./L)	1.83	0.24	0.04
Per cent reduction		87	98

From the tests made to determine volume of sludge to be expected in this process, Mr. Hubbell reported the following data:

Total solids in raw sewage	Avg. 571	Parts per Mill.
Total solids in effluent	Avg. 494	Parts per Mill.
Suspended solids in raw sewage	Avg. 143	Parts per Mill.
Suspended solids in effluent	Avg. 21.5	Parts per Mill.
Suspended solids removed, weighted	Avg. 85.5%	Parts per Mill
Gallons wet sludge drawn (94.1%)	4000.0	Per Mill. Gals.
Sludge lbs. dry weight	1950.0	Per Mill. Gals.
Equivalent 65% cake, lbs.	5560.0	Per Mill. Gals.
Lbs. of lime (62% CaO)	613.0	Per Mill. Gals.
Lbs. ferric chloride (47% $FeCl_3$)	125.0	Per Mill. Gals.
Lbs. paper 10% moisture	426.0	Per Mill. Gals.

*Can be explained by the introduction of large quantities of straw-board pulp which was high in soluble organic matter.

†See front cover on this issue.



Flow Sheet of Dearborn Sewage Disposal Plants

cotta; floor of motor room to be terrazzo and floors of lobby and laboratory to be tile.

A stairway directly opposite lobby entrance leads to a door opening on a truck balcony, or runway, in operating portion of plant. This balcony is approximately 17 ft. above operating floor and provides an excellent place to view complete plant in operation.

The Process.—The process to be employed is purely a chemical and mechanical one. Lime, ferric chloride and paper pulp are added to the sewage which is passed first through a baffled mixing chamber and then into a circular clarifier at the center. The sewage liquor then flows radially outward and finally upward through a 3-in. bed of magnetite, is chlorinated and discharged into the river. Sludge will be pumped to Oliver filters and the sludge cake from the filter will be delivered by belt conveyor to hopper bottom bins and storage pile. The sludge filtrate is returned to the clarifier influent.

Sludge from the east side tanks containing 2 per cent to 4 per cent solids will be treated in the same manner in another clarifier. It is planned to deliver sludge from this clarifier of about 10 per cent solids to the vacuum filter and produce a cake containing about 40 per cent to 45 per cent solids.

A unique feature of the process is the use of pebble mills for preparation of pulp from waste paper and the disposal of grit and screenings as a slurry to the clarifier influent for ultimate disposal in the form of sludge cake. All grit and most of the screenings from both plants will be put through one of two pebble mills to convert them to the slurry. The grit will assist materially as a grinding medium for disintegration of screenings and paper in the pebble mills.

Materials and Equipment Employed.—Paper for pulp will be supplied by the regular city refuse collectors and dumped into bins under the balcony. All kinds of paper, cardboard boxes and containers may be used for this purpose, and it is proposed to operate a bailer-collector wagon which will bail the paper during collection trips.

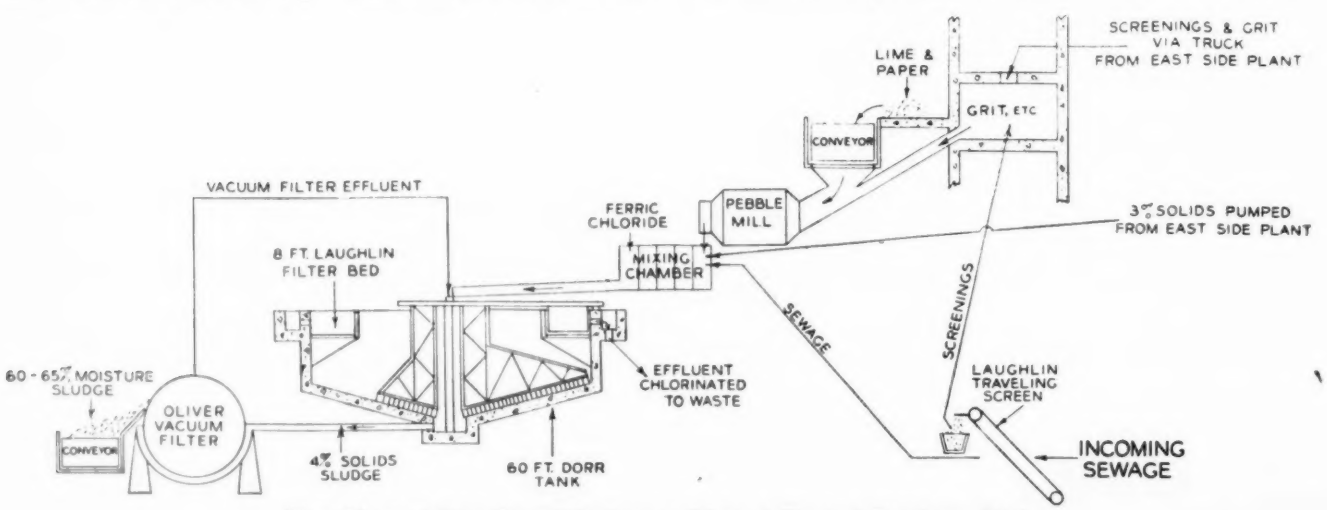
The major quantity of lime used will be in the form of waste sludge from a nearby Prestolite plant. Approximately 75 per cent will be saved by using this material in place of ordinary lime. This lime containing sludge will be trucked to the plant and dumped into bins under truck balcony. Along the front of the bins will be weighing scales and a flight conveyor. The lime and paper will be weighed, pushed onto the conveyor and delivered to a pebble mill. Settled sewage will be pumped to the mill to furnish water for pulp making or preparation of milk of lime solution.

Equipment plans call for the installation of a Mathieson type of ferric-chloride generator. It is planned to use tin cans and bushelings from the city salvage plant in conjunction with chlorine in this generator and thus produce liquid ferric chloride in proportion to the chlorine passed into contact with the scrap iron and cans.

For coagulating the crude sewage, two parallel mixing chambers are provided. Each one is 24 ft. 6 in. long by 4 ft. wide by 3 ft. deep. They have steep sloping sides and are baffled by 7 steel plates. Chambers are to be built of ¼-in. steel plate.

Two 60-ft. circular Dorr clarifiers with sludge scrapers are specified. These have been modified by the addition of the Laughlin magnetite filter as shown in the sketch. One clarifier is to be used for Dearborn west side sewage and one for the sludge pumped from the East Side plant for dewatering at the new plant.

The Laughlin Filter.—This Laughlin filter is constructed around the inside wall of the clarifier at the top. The bottom is a slotted screen of phosphor bronze, 8 ft. wide with openings 1 millimeter in width. On this



Flow Sheet of New West Side Sewage Disposal Plant of Dearborn, Mich.

will be placed a 3-in. layer of crushed magnetite of sizes that pass a 10-mesh sieve but will be retained on a 16-mesh sieve. This material is very heavy, has a specific gravity figure of roughly 5, and is not easily disturbed by upflow of sewage through the shallow bed.

Cleaning of the magnetite bed will be accomplished by a traveling device carrying a solenoid immersed in oil and encased in bronze and also a small pump for returning dirty wash water to clarifier. The solenoid lifts the magnetite up from the screen and results in a temporary upward rush of settled sewage through the screen and suspended filtering media thus washing it. The pulsations and travel of the magnet around the circular filter are synchronized to provide overlapping of filter washing. The wash water escapes over a weir to the box-like pump compartment on the traveling unit and is returned to the tank by the pump unit.

Specifications covering the performance of this filter are as follows: With normal sewage containing from 150 to 250 parts per million suspended solids when operating at a filtration rate of 2 gal. per sq. ft. of screen area per minute, at least 80 per cent of the suspended solids shall be removed by the process. Of this 80 per cent, the Laughlin Magnetite Filter shall remove at least 8 per cent, namely the amount from 72 per cent to 80 per cent.

With normal sewage containing from 150 to 250 parts per million suspended solids when operating at a rate of 1 gal. per sq. ft. of screen area per minute, at least 87 per cent of the suspended solids shall be removed. Of this 87 per cent, the Laughlin magnetite filter shall remove at least 8 per cent, namely the amount from 79 per cent to 87 per cent.

Sludge Handling and Disposal.—As stated above the sludge is to be dewatered on two 8-ft. by 12-ft. Oliver vacuum filters. It is believed that little difficulty will be encountered in reducing its moisture content to between 60 per cent and 65 per cent with these units. It is in dewatering that the paper pulp provides one of its great advantages. Excellent facilities are being provided for sludge delivery to trucks of farmers or others interested in hauling this material away. Two or three additional schemes are to be tried out after the plant is operating looking to solving the ultimate disposal of sludge in an economical manner and among these is incineration.

Plant Capacity and Costs.—The present sewage flow from the west side of Dearborn is estimated at 2.75 m.g.d. It is assumed from experimental scale operations that the present equipment will treat successfully a maximum flow of 8.0 m.g.d. The East Side plant is handling at present 15 m.g.d. The contemplated changes in influent channels and weirs at this plant should make it possible to treat a maximum of 30 m.g.d. if the sludge is dewatered at the new plant. The capacity for sludge handling at the new plant can be increased three times without added clarifier capacity because sludge pumping at present will require not more than eight hours of operation each day.

The cost of treatment using this process is nominal and its nature renders it readily controllable. The land required is comparatively small in area and the process is inodorous and can be located in practically any district of a city. The contract cost for the building and complete pumping and other equipment is approximately $455,000.

The process and especial equipment was developed by W. C. Laughlin of the Filtration Equipment Corporation and the writer. Hubbell, Hartgering and Roth were designers of the superstructure and pumping equipment and furnished plans to the city of Dearborn for the Filtration Equipment Corporation, equipment engineers. The general contractor is the W. H. Mueller Company of Detroit.

It is expected that the plant will be in operation before Jan. 1, 1932.

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Chlorination of New Wells

Within recent years attention has been given to the subject of chlorinating new wells. This procedure, states A. G. Fielder, Hydraulic Engineer, U. S. Geological Survey, in a paper presented at the 9th Annual Kansas Water Works School, may be regarded as an essential part of good construction, particularly where the well is intended as a source of supply for a municipality. During the course of construction considerable contamination may be introduced into the well on the drilling tools or the well casing or by using gravel from sources that are badly polluted. Contamination on the tools is not easily avoided, but gravel can be readily freed from contamination by washing with chlorine solution. A well may be chlorinated under pressure or by simply introducing a strong solution of chloride of lime into the well with a dump bailer. The former procedure is probably the more effective, but it requires special pumping equipment, which is not usually available with cable tool drilling machines. Under most conditions chlorination by introducing the solution with a dump bailer is adequate, but if contamination still exists after a thorough pumping following the dosing of a well in this manner chlorination under pressure may then be desirable, provided the hydrostatic head is not excessive.

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Water Softening at Columbus, O., in 1930

Charles P. Hoover, chemist in charge of water purification at Columbus, O., gives the following in the annual report of the Division of Water for 1930:

During the year an average of 32.4 million gallons of water was softened and filtered each day. This represents 112 gallons per capita per day.

The hardness of the water was reduced from an average of 268 p. p. m. to an average of 85 p. p. m. A reduction of 68 per cent.

To reduce the hardness of the water from an average of 268 p. p. m. to 85 p. p. m., 2,918 tons of soda-ash and 8,766 tons of lime were required. The price paid for soda-ash was $27.60 per ton, and the price paid for the lime was $6.82 per ton, making the total cast for soda-ash $80,536.80 and the total cost for lime $59,784.12. The cost of lime, soda-ash, alum, chlorine and coke per one million gallons of water treated amounted to $12.91.

The average turbidity or muddiness of the river water during the year was 88 p. p. m., whereas the turbidity of the filtered water was zero. The average color present in the river water was 20 p. p. m. By the combined use of lime, soda-ash and alum, the color was reduced in the filtered water to one part per million. A color of one part per million is not noticeable to the consumer.

SLUDGE GAS EXPLOSION AT SEWAGE WORKS, WOONSOCKET, R. I.

ON October 2, 1931 at 11:25 A. M., an explosion of the two sludge digestion tanks at the activated sludge sewage treatment works of Woonsocket, R. I., blew off the roof and killed two workmen. The exact cause of the gas ignition and explosion has not at this writing (Oct. 10th) been determined. The men who might have disclosed the cause were unfortunately killed outright.

Fig. 1.—Looking Across the Sludge Digestion Tank Where the Explosion Occurred. The Original Top Construction Is Shown on the Duplicate Undamaged Tank Beyond. Concrete Was Blown Some Distance Onto the Sand Filters in the Background

The known facts are as follows:

The sludge tank which exploded had been partially emptied incident to transfer of sludge to a parallel tank for "seeding." The manholes in the roof had been opened and one workman had entered Section No. 1 or No. 2 of the three section tank to inspect the sludge conveyor mechanism and had just emerged. The second workman was still down in the third section of the tank in which the explosion apparently started and in which it was most violent. He was standing on a rung of an iron or steel ladder. He was not using any kind of tools. There was yet remaining about 3 ft. of partly disgested sludge in the tank. All metal work was reported to be wet at the time.

Sludge-tank gas had been burned prior to the inspection for the purpose of heating the digestion compartments. Prior to transfer of sludge to the other digestion tank alongside (Fig. 1) gas burning had been discontinued and no gas was being burned at the time of the inspection and explosion. There was one lantern on hand at the plant which was not used, as evidenced by the fact that it was found in the control house after the explosion. The shoes worn by the man down in the tank were examined for projecting nails but it seems doubtful to those who inspected the shoes that these nails could have been the cause of a spark being generated by friction with the metal of the ladder which was also probably wet. The soles were tacked on but were of rubber composition.

When the explosion occurred the man in the tank was blown out into the field and all clothing had been stripped from his body. The other man was thrown upward with the roof from the adjoining section and some time afterward the body was found inside the tank down in the sludge. Two men standing on top of the gas chamber (see Fig. 2) at the time of the explosion were not injured.

From all available information it seems to be the consensus of opinion of those on the grounds at the time, and through checkups made subsequently, that the explosion was probably due to thoughtlessness on the

Fig. 2.—Close Up of the Center Channel of the Digestion Tank Gas Chamber and Domes Appear in Rear and Furnace Room Where Gas Is Burned Is Just Beyond. Explosion Apparently Started in End Nearest Reader

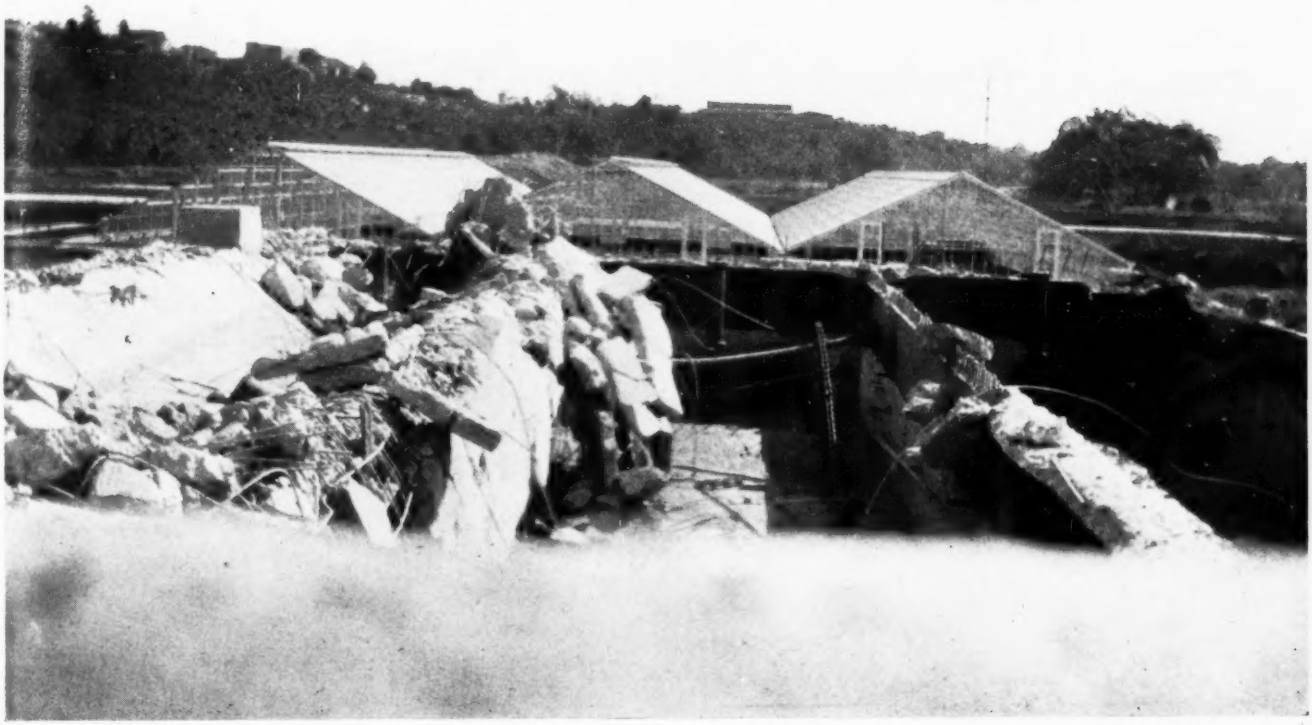

Fig. 3.—Looking Toward End of Tanks Where Explosion Exerted Greatest Force. Manhole Remaining on Left Section of Tank Is One of Six Through Which Men Entered for Inspection. One Man Killed Was Down in the Compartment on the Right. The Other Man Was Standing on the Roof of the Center Compartment. Considerable Damage Was Done to the Glass Covers Over the Sludge Beds in the Rear

workman's part in that he was of the type to tempt Providence and must have struck a light while in the tank. No mention has been made of his having had a flash light and apparently none was found. The manholes on the tank had been open for some time prior to the inspection in order to ventilate before entry.

For a complete description of the Woonsocket plant —illustrated with drawings of design—see WATER WORKS AND SEWERAGE, Vol. 77, p. 339-343, October, 1930: "Activated Sludge Treatment Plant for the City of Woonsocket, R. I."—Philip B. Streander.

Acknowledgment.—The photographs accompanying this report were supplied by C. L. Pool, State Sanitary Engineer, of Rhode Island.

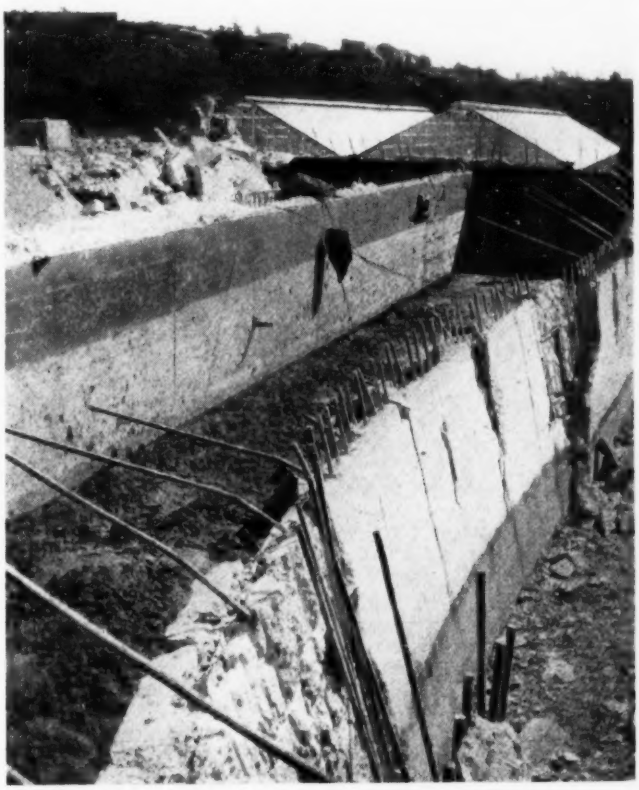

Fig. 4.—Wall Separating Channels of Sludge Digestion Tank. View Taken from Roof of Raised Gas Chamber Which Was Ruptured but Not Blown Out. See Fig. 2.

A Plan for Unemployment Relief by Public Works Construction

A proposal for the construction of water works improvements and other revenue producing public works as a means for furnishing work for the unemployed, was presented to the New England Water Works Association at its recent convention. The plan was submitted in the form of a resolution by a committee consisting of Malcolm Pirnie, Stephen H. Taylor and George C. Brehm. The resolution was adopted by the association on Oct. 1. The resolution follows:

WHEREAS, steps are now being taken in many states to raise and appropriate funds for the relief of unemployment, and

WHEREAS, such relief may take the form either of a dole or of a compensation for time and labor given to the state or community that provides the funds, and

WHEREAS, it is generally agreed that the dole is not desired either by the unemployed or by those who would be taxed to raise the funds, and

Fig. 5.—View of Woonsocket, R. I., Sewage Works. Taken from Roof of Gas Chamber Following the Explosion. Chimney from the Furnace Room Is in the Right Foreground. Gas Trap Appears in Left Foreground Undamaged by the Explosion

WHEREAS, in most urban communities there exist needs for additional public facilities, to provide which would produce employment for many if not for all who are now unemployed, and

WHEREAS, the present financial burden on real estate is so great that it would be unwise, if not impracticable to authorize expenditures for new facilities which would be an added lien on real estate, and

WHEREAS, water works, gas and electric properties are revenue-producing and are self-supporting with proper rates in force, water works being largely municipally owned, and

WHEREAS, water works distribution systems are universally in need of reinforcement, particularly in the residential sections and many communities need additional water supply works or water purification works, and

WHEREAS, privately owned water, gas and electric properties in various communities are in need of improvements to provide satisfactory service, money for which can be secured if the rates in force are equitable, and

WHEREAS, at present both materials and money can be secured considerably below normal costs, making this an ideal time for investment in needed public works.

BE IT THEREFORE RESOLVED, that the New England Water Works Association assembled in its fiftieth annual convention urges that the funds to be expended in unemployment relief be applied to the provision of needed water works and other revenue producing public works substantially in accordance with the following program:

Proposal to Provide Useful Work Instead of a Wasteful Dole.—Call upon each of the urban communities in the political subdivisions charged with the administration of unemployment relief funds to take care of its own unemployed.

For example, the urban population of New York State is more than 10,000,000 and it is estimated that all unemployment is in urban communities.

Instead of raising $20,000,000, as authorized in New York State, through taxes on incomes in one year, raise $7,000,000 per year for three successive years, amounting to 70 ct. per urban capita.

Notify all communities having populations of 1,000 and more that 70 ct. per capita will be paid to them from the unemployment relief fund to be used to pay interest on bonds for improvements to revenue-producing properties, for a period of three years. After this the community will assume its own interest payments and presumably at the end of the first five years will also assume its own amortization of bonds issued.

Seventy cents per capita is the interest at 4½ per cent on $15.50 per capita. This means that the interest for three years will be guaranteed to urban communities in the state on a total of $155,000,000 worth of construction work applied to revenue-producing properties. * * * *

The above figures are based on average performance by all urban communities. * * * *

General Benefits.—The principal result of such a program will be to initiate at least $150,000,000 worth of work to give employment, instead of attempting to distribute $20,000,000 equitably among 900,000 unemployed. * * * *

What this means on the average to communities of various sizes in the state of New York is indicated in the following table:

Population, in thousands	Number of communities	Average value of construction in each community	Total value of construction
1 to 2.5	146	$ 30,000	$ 4,380,000
2.5 to 5.0	46	60,000	2,760,000
5.0 to 10.0	41	120,000	4,920,000
10.0 to 25.0	47	300,000	14,100,000
25.0 to 600.0	22	1,100,000	24,200,000
New York City	1	105,000,000	105,000,000
			$155,360,000

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

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THE USE OF CHARCOAL AND ACTIVATED CARBON IN WATER TREATMENT

1. Early User of Charcoal and Animal Char for Water Filters

THE widespread interest in the use of activated carbon for removing objectionable tastes and odors from water justifies a fairly extended treatment of the subject at the present time. Carbonized materials such as charcoal and bone char have had a limited use in water treatment for more than a hundred years, a fact perhaps not known to many now engaged in water treatment. The construction of filtration plants using sand for the filtering medium almost completely supplanted the carbonized materials, which, while not used extensively in large filters, were used fairly extensively in household filters. As a filtering medium for the clarification of water there is now no doubt about sand being the cheapest material to use. There are many instances, however, where filtration, or coagulation and filtration does not produce water entirely free from tastes and odors, and it is in these places where the activated carbons of today may be used to advantage.

This article will be divided into three parts. The first part will give a history of the use of charcoal and bone char up to the time of the beginning of the use of the more active materials in 1929 and 1930. The second part will deal largely with the development of activated carbon, the theory of adsorption, the type of compounds that will be adsorbed, and the methods of testing the activity or adsorptive capacity of carbonized materials. The third part will review progress up to date in the use of activated carbon for removing objectionable tastes and odors from water. The first part is justified by the fairly extensive use of charcoal and bone char for household filters before the construction of municipal filtration plants, and to the fact that the literature on the subject is not now readily available to those engaged in the design or operation of purification plants. The second part of the article is justified on the assumption that designing engineers and filtration plant operators have a fair knowledge of chemistry, and that they can handle such materials to better advantage when they understand their characteristics and limitations.

The writer does not intend that this be considered a complete history of the use of charcoal and bone char in water purification, for some of the scientific literature published 50 to 100 years ago is not now readily available. It is believed, however, that enough has been found to give a fairly good account of the early uses of such materials.

Earliest Uses of Charcoal in Water Purification.—There seems to be no exact record when charcoal began to be used as a purifying agent for water, though there is evidence that it dates back prior to 1800. Humber[1], in 1876, states that: "Charcoal, especially animal charcoal, has always been popularly regarded as a very powerful medium for the removal of organic impurities from water filtered through it." Mantell[2] states that Larvitz recognized the deodorizing and decolorizing effect of vegetable carbons as early as 1792, and that Kehls, in 1793, found that carbon obtained from animal tissue also possessed the property of removing colors from solution.

The earliest reference which was found on the purification of drinking water with charcoal was by Sir John Sinclair[3] in 1807. "Another mode of improving water, and one that has been most recently discovered, is by means of charcoal, a substance which enjoys the property of preserving water from corruption, and of purifying it after it has been corrupted. It has been found, that one ounce and a half of powdered charcoal, and 24 drops of oil of vitrol, are sufficient to purify three English pints and a half of corrupted water, without communicating to it any sensible acidity. If no acid be used, two-thirds more of charcoal powder will be necessary. . . . . It is said, also, that filtering the water through charcoal has been found an excellent mode of purifying it."

The addition of 24 drops of concentrated sulfuric acid to less than one-half gallon of water might make the water chemist of today doubt that it could be consumed afterwards. Certainly there is little doubt about the water being made sterile after such a treatment if the acid was added first. The acid was neutralized by the alkali in the charcoal, and it is likely that the water was very palatable after the treatment. Very highly polluted water likely could be made safe by such a treatment. Bacteria had not been discovered at that time and waters that were likely to cause illness were spoken of as being corrupted.

Cities began to distribute water in pipes through the streets to the inhabitants in the early part of the 18th

century, and it likely was not long afterwards before the water was piped into buildings. The frequent use of charcoal filters to improve the quality of the water probably started shortly after the introduction of plumbing into buildings. Abraham Booth[4], in 1830, stated that putrescible vapors may be removed from water by filtration through charcoal. An article in the *Journal of the Franklin Institute*[5], in 1828, credits Lowitz with discovering the antiputrescent and bleaching properties of charcoal. Emmett[6] describes the use of powdered charcoal for bleaching flax. The flax was submerged in soft water and was allowed to stand in contact with powdered charcoal for 24 hours. This was probably a case where the flax gradually gave off color to the water, and the color was rapidly adsorbed by the charcoal.

It is thus seen that some of the main properties of charcoal and bone char were fairly well understood over a hundred years ago.

Household Filters.—The first large sand filtration plant for purifying the water of a public supply was constructed by the Chelsea Water Works Company of London in 1829. The method of filtration was what is now known as slow sand filtration, the water being passed through beds of sand about 3 ft. in thickness. It is not believed that a project of this magnitude would have been undertaken without considerable information that sand would clarify the water, and it is likely that this knowledge was gained from experience with small sand filters. It is believed that both sand and charcoal filters for individual buildings were being used in cities possessing a turbid and unpalatable water supply a number of years before the construction of the first large sand filtration plant. In fact some of the literature refers to the construction of filters in England and Scotland in the first decade of the 19th century.

Humber was not strictly correct in stating that charcoal filters have always been used, though very likely from his earliest recollection he had heard reference to the use of charcoal for the purification of water. The earliest patents on household filters in the United States refer to the filtering medium being sand, charcoal, felt, sponge, etc. Many patents have been issued on filters of various kinds, the majority of which are for small filters suitable for homes, hotels, apartment buildings, office buildings, etc. Naturally there were a great variety of designs, yet most of them were so constructed that charcoal might be used in the place of sand or other material. Most of the filters were constructed so that the packing or filtering medium could be easily removed for cleaning or replacing. Perhaps most of the filters were for attaching to the water pipes to avoid handling the water by hand, though there probably were many detached filters in use, especially where there was no plumbing in the building.

There is no information as to the percentage of buildings using small filters years ago where the water supply was not filtered. Practically all cities where the water is very turbid now have large filtration plants for filtering all the water and there is no way of estimating the percentage of homes and other buildings that would have private filters if the water was not filtered. It is believed that fully 25 per cent of the homes in a small city, of which the writer has some knowledge, had private filters prior to the construction of the filtration plant. The water was fairly turbid at times. This is too high a figure to place on the homes having filters 50 to 70 years ago when only a few cities had filtration plants, yet the percentage was fairly large where the water was very bad.

Early Use of Household Charcoal Filters.—There probably was very keen rivalry at one time between the advocates of sand and charcoal household filters, though as previously stated most of the types were so constructed that either or both materials could be used. For highly polluted water, especially water having an objectionable taste and odor, charcoal or bone char filters were almost invariably recommended. J. C. Dahlke[7], in 1861, read a paper before the London Society of Arts in which he stated that about 70 years ago filters were introduced into England containing three layers of media, namely, sand, gravel and charcoal. This would date back to about the time of the Peacock patent. He stated that charcoal has now become the most common filtering medium, and that animal charcoal was the most efficient. As a substitute for animal charcoal, Dahlke found that the residue of bog-head coal, obtained after it is distilled from coal oil, answers a most excellent purpose when well burned.

Dahlke[8], in 1860, patented a process of making carbon plates of any desired shape for use in household filters, cisterns, on board boats, and in large filter plants for water works. Animal charcoal, powdered quartz, coal tar and fire clay were mixed to form a stiff paste, molded into the desired shape, and then exposed to a gradually increasing heat in a closed vessel. The plates were kept red hot for about 3 hours. The advantage of using the plates is that they may be removed from the filter when they become foul, scrubbed, and again heated in a closed retort when they become as good as when new.

Engineering[9], 1867, in giving an account of the filters on exhibition at the Paris Exhibition makes the following statement: ". . . . . but the English Nation must, in this matter, be fairly said to be represented by the Silicated Carbon Co., Battersea, who make a magnificent display, ..." Their agent reported that the refrigerative filter was the favorite.

One type of charcoal filter used to a certain extent in England was described by Prof. Wm. Ripley Nichols[10] as being constructed according to the best principles. It was manufactured by the London and General Water Purifying Co., and consisted of an earthenware filter-box filled with animal charcoal and located in the bottom of a float-controlled tank several times the size of the filter. The filter was completely submerged in the tank, and had a pipe leading from the top of the filter through the bottom of the tank. The water passed upward through the charcoal so that suspended matter settling downward would not be deposited upon the filtering material and help to clog the pores. When cleaning was necessary the filter was unfastened from the outlet pipe, removed from the tank, and the charcoal replaced.

Philbrick[11], 1878, in referring to the desirability of filtering cistern water, states that the mechanical filters using brick, gravel, sand, or sponge are useless in removing dissolved impurities from the water. Recourse in such cases must be had to a charcoal or spongy iron filter, which acts chemically upon various substances in solution, burning them up as it were by the oxygen within the filter. It might be said that adsorption by carbon was not very well known at that time, and as the organic compounds were removed from the water and could not be washed from the carbon it probably was assumed that they had been oxidized. There is

not much evidence to support such an assumption at the present time, except that many organic compounds in water are being oxidized gradually by the dissolved oxygen in the water. There is no proof that carbon hastens the reaction, though it may do so. Philbrick's reference to mechanical filtration by straining out the suspended solids with sand, etc., as distinguished from removal of dissolved organic compounds by charcoal may be the true origin of the term "mechanical filtration."

One inventor patented (British Patent No. 3,879, Sept. 26, 1879) the carbonization of excrement, waste matter of all kinds, and sewage, for the manufacture of filtering carbon. There is no doubt about it being possible to make filtering materials from some of these materials, but the cost very likely would be excessive.

The Plumber and Sanitary Engineer[12], 1880, says that the most efficient charcoal for filtering in a cistern is animal charcoal or bone char. The part of the cistern where the pump suction is located may be partitioned off so that the water entering this part of the cistern has to pass through a bed of charcoal. Again *The Plumber and Sanitary Engineer*[13], 1880, in reply to an inquiry as to how to construct a house filter, states that if dissolved organic matter has to be removed, granulated charcoal should be used in the place of sand.

Methods of revivifying the charcoal in a filter without removing it from the filter with an alkaline solution and with superheated steam were patented by Jennings in 1881 (U. S. Patents Numbers 239,961 and 239,962).

Prof. Frankland[14], 1882, made extensive experiments on methods of purifying water and came to the conclusion that animal charcoal could be used with safety only with waters of considerable initial purity, and when so used it was necessary to frequently renovate by heating in a closed vessel. Hett[15], 1884, states that for large works sand filtration still takes the leading place, and that household filters are most commonly furnishing with animal carbon. He also states that neglected animal charcoal forms a nursery for minute organisms. In the large cities where the animal charcoal is kept in proper order by the maker's employees, there is little left to be desired. Hett further states that compressed carbon blocks, such as Adkin's and the Silicated Carbon Company's, appear to be free from the objections which apply to loose charcoal.

Attempts to Use Charcoal Filters for Municipal Supplies.—The success of the charcoal and bone char filters for household uses naturally led to these materials being tried for municipal supplies. The successful use of animal charcoal for filtering the East London Company's water in lodging houses with 700 occupants in Columbia Square, London, 1866[16], led to an agitation for its use on a larger scale. Some advocated filtering the entire London supply through beds of animal charcoal. Byrne[17], 1866, made an investigation of the use of charcoal and bone char for water filtration and came to the conclusion that it was not suitable for a large supply. There was quite a lengthy discussion of Byrne's paper[18], with several of those discussing the paper disagreeing with the author. Dr. Letheby took a prominent part in the discussion, and while he agreed with Byrne that charcoal probably was not suitable for the filtration of a large supply, he did not agree with him that it was not suitable for small filters. He offered as evidence, tests on charcoal which had been in service in a filter 2 years. When water supplied by the East London Water company was filtered through charcoal at a rate that there was a contact of about 3 minutes the water was deprived of its color and organic matter. Dr. Letheby stated that animal charcoal had the power of bringing the oxygen dissolved in the water into chemical union with organic matter, and of destroying it.

Thomas Spencer patented (British Patent No. 240, Oct. 5, 1866) a compound known as magnetic oxide of iron. This was prepared by heating red hematite ore with hardwood sawdust for 5 to 6 hours in a closed retort. There may be doubt about the charcoal formed from the sawdust adding materially to the effectiveness of the iron oxide in purifying water, and it probably was not the inventor's idea that it did play a prominent part, except to make the iron oxide more effective in purifying the water. Regardless of whether it was the carbon or the iron oxide that did most of the purifying, a material of some merit was produced. *Engineering*[18] describes the construction of two filter beds at Wakefield of 500 sq. yd. each, having a layer of 9 in. of Spencer's oxide overlaid with sand. Two more beds with an area of 600 sq. yd. each were soon to have a layer of the oxide. It also was stated that beds of this material were in use at Southport and Wisback.

Kirkwood[19], 1869, describes and illustrates the filtering house for the Leghorn Water Works. The water came from a number of springs, which were brought together at the filter house. In 1866, about 568,000 gal. were being filtered daily. The water chamber of the filter house was divided into seven divisions. The bottom of the first five divisions were covered with a filtering material composed of gravel and charcoal. First there were a layer of gravel, 8 in. in thickness, a 12-in. layer of wood charcoal, an 8-in. layer of coarse gravel, and a 12-in. layer of fine gravel, or a total depth of 40 in. Placing the charcoal between layers of gravel seemed to be common practice at that time.

Croes[20] describes 22 filtration plants constructed in America between 1852 and 1883 in which charcoal was used. The cities are listed in Table I.

Croes states that the first attempt at filtration through layers of sand and charcoal was made at Elizabeth, N. J. The filter is said to have had 1,000 cu. ft. capacity. A similar bed was constructed at Malone, N. Y., to filter a supplementary supply from the Salmon River. At the University of Virginia the water of an

TABLE I—PLACES WHERE CHARCOAL FILTERS HAVE BEEN CONSTRUCTED

Date Constructed	Locality
1852	Elizabeth, N. J.
1857	Malone, N. Y.
1868	University of Virginia.
1868	Barrington, Mass.
1874	New Milford, Conn.
1875	South Norwalk, Conn.
1877	Marshalltown, Iowa.
1878	Keokuk, Iowa.
1878	Ottumwa, Iowa.
1880	Stillwater, Minn.
1880	Hannibal, Mo.
Not given	Tioga, Pa.
Not given	Athol, Mass.
Not given	Richmond Furnace, Mass.
Not given	Hornellsville, N. Y.
Not given	Peterborough, Ont.
Not given	Cheshire, Mass.
Not given	Bethel, Conn.
Not given	Tarrington, Conn.
Not given	Walton, N. Y.
Not given	Oneonta, N. Y.
Not given	Thomaston, Conn.

impounding reservoir passed into a chamber through double brick walls, 15 in. apart, with the intervening space filled with charcoal. A filter of gravel and charcoal was constructed at the outlet of the storage reservoir at Barrington, Mass. At Milford, Conn., a brick chamber was built in the storage reservoir and filled with gravel and charcoal through which the water passed upwards. The filter at Marshalltown, Ia., was 32 by 16 ft. A floor of 2-in. planks was perforated with ¾-in. holes and covered with wire gauze. On this was laid 4 in. of charcoal and 14 in. of sand and gravel. The bed at Keokuk, Ia., was 50 by 15 ft., and had 2.5 ft. of gravel, charcoal and sand. The capacity was about 600,000 gal. daily. The water passed upward through the filter. The bed at Stillwater, Minn., was 100 by 50 ft., and had 10 ft. of gravel and charcoal.

At South Norwalk, Conn., the water from the reservoir passed through a chamber 3 by 10 ft. and 18 ft. deep, divided into three compartments and separated by wire screens. The first compartment was filled with 6 ft. of charcoal, the second with 16 in. of sponge, and the third with clear water. Similar filters were constructed at Bethel, Tarrington, and Thomaston, Conn.; and Walton and Oneonta, N. Y. The filter at Hannibal, Mo., had 3 ft. of sponge and 2 ft. of sand, gravel and charcoal.

Carbon for dechlorination has been used to a limited extent for over 20 years. The Candy Filter Company's process of dechlorination was known as the "De-Chlor System." A plant using this system was installed for the Reading Corporation (England) in 1910, which has been described by Walker[21]. The quantity of water treated was about 200,000 gal. daily. The unit was 8 ft. 3 in. in diameter, and had a compartment with a 20-in. layer of prepared granulated carbon or charcoal. The rate of passing the water through the carbon bed was about 2.5 gal. (Imperial) per square foot per minute, or about 3.0 U. S. gal. per minute. In 1916, Frank and F. Pullen Candy obtained a patent (British Patent No. 10,705) on the use of brown coal or lignite for dechlorinating water. The patent stated that this material was more effective for dechlorination than carbonized lignite.

It is evident from the water purification literature that a real effort was made to use charcoal filters. With our present knowledge of the materials used, it is easy to see why they were not successful. It was not from lack of knowledge of the performance of charcoal in filter beds that led the engineers 35 to 40 years to abandon further efforts to use such materials on a large scale.

Charcoals Used Years Ago Did Not Have Sufficient Adsorptive Capacity to Make Them Practical.—The main reason why charcoal did not meet with success years ago was that it had a very small adsorptive capacity. Not only this, but it was used in many instances as a filtering material where it is likely that the pores were soon stopped up by the suspended matter in the water. Adsorption was not very well understood years ago, and many did not realize that even though fresh charcoal or bone char was very effective in removing certain dissolved organic compounds from water, it soon reached a condition where no more of the compounds would be adsorbed. The prevailing idea probably was that the adsorbed material was changed to some inoffensive compound as soon as it was removed from the water instead of being retained on the surface of the carbon. It is probable that some of the adsorbed compounds do change after being adsorbed, but the change is not such that the carbon will not eventually reach the point where it fails to remove all the objectionable compounds from highly polluted water.

Years ago no one knew how to make the charcoal more active. It was just ordinary charcoal or animal char, which we now know is not very active; that is, it does not have a very high adsorptive capacity. Tests on such materials show that their adsorptive capacities are only a very small percentage of that of the highly active carbons now on the market. The phenol adsorptive capacity of ordinary wood charcoal or bone char is usually less than one per cent of the highly active carbons. These inactive materials were the materials tried for water purification years ago, and were partially successful for household filters, though not for larger filters. With materials having an adsorptive capacity more than one hundred times that of the early materials, it is evident that we are dealing with a different problem. We should not let the failure of the inactive materials prejudice us against the use of carbons that will now give efficient service over a fairly long period.

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THE USE OF POWERED ACTIVATED CARBON AT NORFOLK AND NEWPORT NEWS, VIRGINIA

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R. W. Fitzgerald

THE first experimental work with powdered activated carbon in the state of Virginia was conducted early in 1931 at Suffolk plant of the Portsmouth water supply. This experiment was made possible through the courtesy of W. L. Davis, General Manager of the Portsmouth Water Co. and was conducted under the supervision of Richard Messer, Chief Sanitary Engineer, of the State Department of Health assisted by F. E. Stuart of the Industrial Chemical Sales Co.

The primary object of the experiment was to determine what effect "Nuchar," a powdered activated carbon, would have upon waters of low alkalinity and containing large amounts of vegetable coloring matter and numerous species of algae. The results were very interesting and encouraging.

During the experiment E. F. Dugger, General Manager of the Newport News Water Co., visited the Suffolk plant and became interested to the extent of planning experimental treatment in his own plant. The necessary material was obtained for the experimental work but before Mr. Dugger could begin his experiment an emergency arose which gave an excellent opportunity for testing the merits of activated carbon. It became necessary for a short period to take water from one of the lower levels of the reservoir. This water was practically devoid of dissolved oxygen and had a very disagreeable taste and odor. A temporary installation was made to apply powdered activated carbon just prior to filtration. The feeding equipment consisted of a barrel container equipped with an electrically driven agitator and control outlet valve. The carbon suspension was fed into the filter influent through a hose line. The valve was regulated to empty the barrel in approximately one hour. The amount of carbon used was 5 lb. per hour. At the rate of four and one-half million gallons daily the calculated dosage was one-tenth of a grain per gallon.

Nine hours after beginning this treatment the effluent was practically tasteless and odorless. Frequent tests showed an increase in plant efficiency, contrary to the general belief that the finely powdered carbon might pass through the filters. Mr. Messer, Mr. Stuart, and the writer were present during the test run. The high efficiency of the treatment led to its permanent adoption at the Newport News plant. The results at Newport News thus far have been very satisfactory. Complete taste and odor removal has been obtained at a cost of roughly 70 ct. per million gallons. Filter runs have been slightly increased rather than decreased and no carbon has passed through the filters.

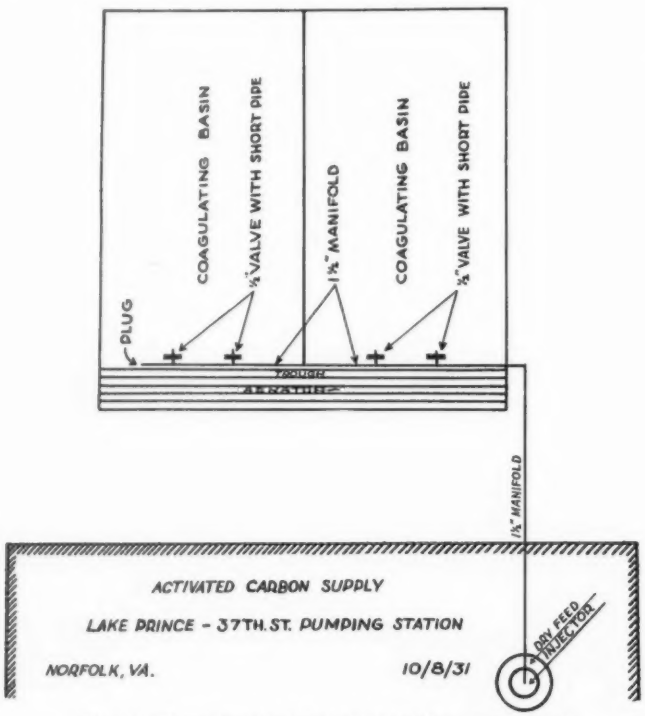
After discussing at length with the writer the results obtained at the Newport News plant, Mr. Charles Bliven, Superintendent of Division of Water Supply of the city of Norfolk, authorized a trial run, using powdered activated carbon at the 37th Street Norfolk plant. This demonstration was made possible through the cooperation of the Industrial Chemical Sales Co. whose representative was present. A grade of powdered carbon known as "Nuchar No. 2" was employed in varying dosages during the experimental period.

The Norfolk, Va., Installation Showing the 1½ in. Carbon Manifold Line with Four ¾ in. Gate Valves

The tastes and odors present in the Norfolk supply were largely due to algae. The predominating species being Synedra and Asterionela. The high organic content of the water also contributed to the disagreeable tastes and prior to the use of powdered activated carbon numerous attempts at taste and odor removal had been

practiced. The methods used were heavy prechlorination, and aeration and also ammoniation of the raw water and filtered water prior to chlorine application but none of these treatments proved to be entirely satisfactory.

At the time of application of the carbon treatment the treatment consisted of heavy prechlorination, aeration, coagulation and sedimentation, filtration and ammonia-chlorine treatment of the filtered water. The only change in this treatment during the experimental run was the addition of carbon. Carbon was first added at the 37th Street plant on June 30th, 1931 through the use of a Wallace and Tiernan type "0" dry feeder, equipped with a water ejector. The carbon suspension was applied to the aerated water entering the coagulating basins through use of a manifold as shown by the accompanying illustrations. This manifold consisted of a 1½ in. pipe together with 4½ in. gate valves to regulate the distribution. The application



Sketch Showing Method of Applying Powdered Activated Carbon

was made prior to sedimentation in an attempt to stabilize the sludge and to secure a longer contact period. Due to the extreme lightness of this material contact with a part of the carbon was maintained for approximately six hours through the settling basins on to the filters. The average dosage of carbon during the experimental run was 1½ parts per million at a cost of 62½ ct. per million gallons. The results obtained were not as immediate as those at Newport News and it is the writer's opinion that the reason for this was that it was necessary to stabilize all of the sludge already in the settling basins and to build up carbon deposits on the filters. After five days time however, increasingly satisfactory results were obtained and it was interesting to note that an immediate decrease in chlorine demand was obtained in the final effluent. This we believe to have been due to absorption of organic matter by the carbon particles.

During the experimental run at the 37th Street plant, severe tastes and odors were encountered at the Moore's Bridges plant also. The application of powdered activated carbon was begun there, and it being desirous to obtain immediate results, the material was applied just ahead of the filters. Within 12 hours time good results were had, and the taste practically disappeared within 36 hours. The average dosage at the Moore's Bridges Station was two parts per million, costing 80 ct. per million gallons but the dosage was later reduced to 1½ parts per million with very effective results. Due to these highly satisfactory results the permanent use of activated carbon at both of the Norfolk water purification plants has been authorized.

It was our thought at first that the carbon application would be discontinued entirely when taste troubles ceased. When the carbon treatment was stopped however there were complaints which resulted in resumption of the treatment but at a reduced rate. The improvement was sufficient even with the minor dosage to warrant the slight expense incurred for a small continuous application which will be increased during periods when the minimum dosage does not handle the situation.

After two and a half months of close observation of the carbon treatment at the Norfolk plants, the writer has drawn the following conclusions:

1. Tastes and odors can be economically controlled by the use of powdered activated carbon.
2. Sludge can be stabilized as shown by the doubling of the periods between basin cleanings. (The cost of the water thus saved is an important economic factor in plant operation.)
3. The use of ammonia has been found unnecessary when carbon is applied and has been discontinued.
4. Accurate tests have shown that the carbon particles have not penetrated the filter beds to a depth greater than 10 in. and the shortening of runs has been a negligible factor.
5. The most effective point of carbon application can best be determined by test runs, and economy results from cut and try procedures to determine the minimum effective dosage.
6. Because of the small additional expense compared with the benefits, the use continuously of a small dosage of carbon is justifiable as "insurance" against taste troubles.

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Chromium Nickel Steel Alloy Bolts Used for Pipe Fastening in Sea Water

Heavy U-bolts of Allegheny metal, the chromium-nickel steel alloy, were used to fasten a 24-in. cast iron gas siphon to its support under the waters of the Island End River, at Everett, Boston, in a construction job recently finished for the Boston Consolidated Gas Co.

The line was constructed by Hugh Nawn, Inc., contractors, of Boston. It was necessary to support the pipe to guard against any possible settling in the future; the pipe was laid in salt water and is in the neighborhood of chemical plants.

The engineers decided that it was necessary to use two pile bents with a cap over the siphon, and to use two U-bolts passed under the siphon and connected to the cap as a support. Allegheny metal was chosen for the U-bolts, washers and nuts after an exhaustive investigation into the corrosion-resistance of various materials. The work was done by divers working under 30 ft. of water.

The U-bolts are of 1½-in. Allegheny metal rod and are 11 ft. long. They were fabricated by the Henrici Washing Machine Company of Boston.

TUBERCULATION OF MAINS AS AFFECTED BY BACTERIA*

By **H. G. REDDICK and S. E. LINDERMAN**
United States Pipe and Foundry Co., Burlington, N. J.

ONE of the most baffling problems which confronts waterworks men today is the tuberculation which forms on the inside of pipe lines in various localities. Tuberculation was doubtlessly observed on some of the oldest installations of cast iron pipe within a comparatively few years after installation.

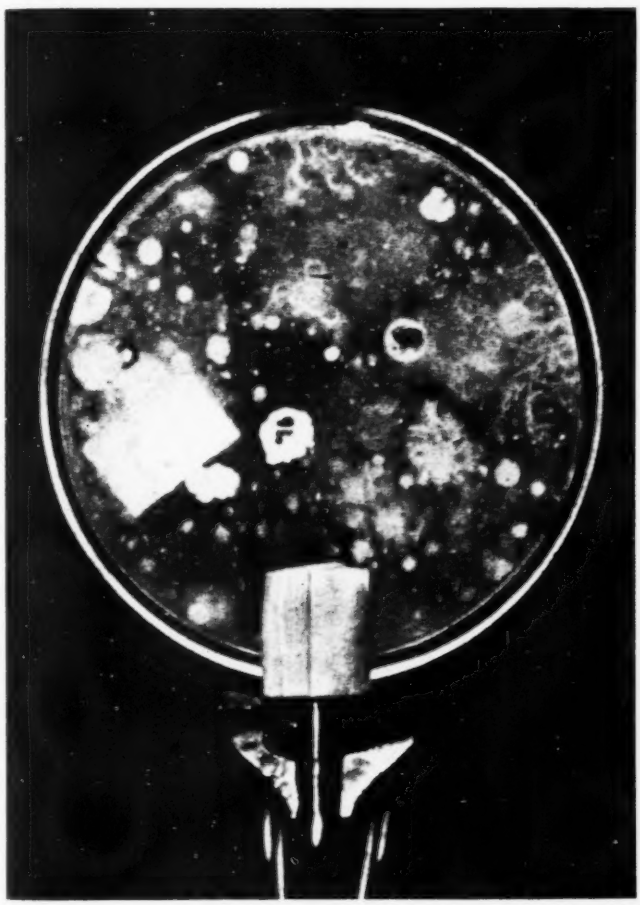

Plate 1—Iron Depositing Bacteria on Agar Plate

Previous to the middle of the nineteenth century little consideration had been given to this phenomenon. The effect of tuberculation upon pipe lines laid prior to the use of protective coatings where tuberculating waters were carried, has been serious and modern water works engineering demands the use of some form of protective coating on iron and steel pipes.

A tubercle has been described as follows: A limpet-like structure arising from the surface of iron. In time the surface becomes studded with these objects much the same as a ship's bottom becomes covered with barnacles. Each one of these incrustations consists of a cone like structure which grows by the addition of concentric layers. The central portion is black and soft when fresh. This black substance often contains a small percentage of sulphide of iron and becomes red upon exposure to air. The middle layers are composed of ferric oxide. The outside layers are composed for the most part of ferric oxide interspersed with hard black layers of magnetic oxide of iron.

In a report issued by the New Bedford, Mass., Water Board in 1913, extended mention is made of considerable tuberculation in their pipe lines, both steel lines and cast iron lines. Regarding the tuberculation of cast iron pipe at New Bedford, the report states:

"In the cast-iron pipe, the tubercles themselves have grown considerably in size. The extent of this growth is best indicated by the four outer rings, which can be clearly seen on photographs, showing the under or contact side of tubercle. Photographs showing the top and side view of sample tubercles from the cast-iron are also submitted."

Although the authors have not examined the tuberculation specimens from New Bedford, specimens were obtained of old cast iron pipe, which had been in service in Falmouth, Mass., Burlington, N. J., Philadelphia, Pa., Louisville, Ky., Petersburg, Va., and Chicago, Ill. Examination of the tuberculea revealed that all of them possessed very similar characteristics, that is, as regards analyses, magnetic properties and nodular formations.

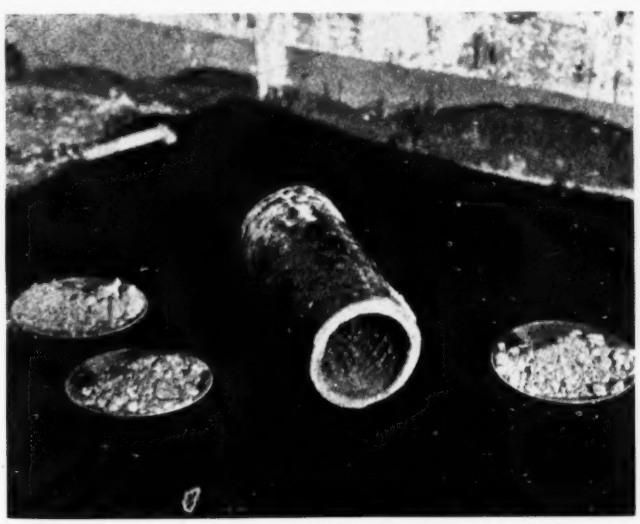

Plate 2—Pipe Which Was Closed by Tuberculation Without Noticeable Corrosion Having Taken Place

Furthermore, all of these tubercles are magnetic as is bog ore and contain water of hydration, as does bog ore. All of these tubercles seem to be nodular excrescences grown by accretion and formed of concentric layers as is limonite. Limonite or brown hematite ores are nodular in character like the inside of a tuberculated pipe where the tubercles are closely packed.

That these nodular excrescences, or tubercles, found

*Excerpts from a paper presented before the New England Water Works Association, Boston, Mass., Sept. 30, 1931.

on the inside of cast iron pipe are of bacterial origin it is the pleasure of the authors to present substantiating data.

Naturally with such evident similarity which was found between the tubercles and the bog ores, it was only natural to assume that it is quite possible that these two products are formed in much the same manner.

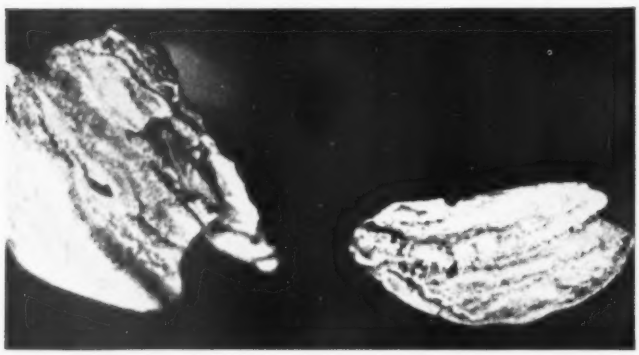

Plate 3—Tubercules of Iron Oxide Formed in Pipe by Micro-Organisms, Taking Iron from the Water

Several bacteria have been isolated from time to time which show a decided ability to precipitate iron oxide out of solutions of iron salts. As to just how this is accomplished is a debatable question. Some investigators believe the reaction is physiological, others that it is purely mechanical. However, be that as it may, biological activity is responsible in many instances where tuberculation takes place.

It is well recognized and know that bacteria of certain defined types, known as higher bacteria, are potent if not sole factors in the formation of bog ores, brown hematites, as well as ocher beds and brown ironstone clays. They possess the ability to collect iron, some times in their bodies, some times on the outside of their bodies. In the case of bog-ores and limonites they

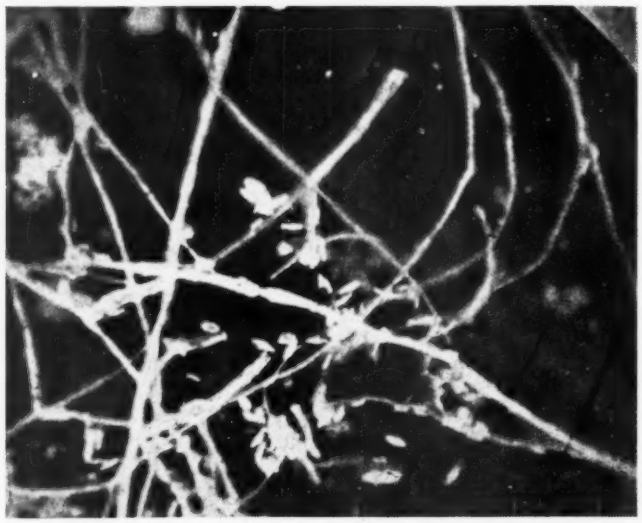

Plate 4—"Ironmongers," Spirophyllum and Lepthothrix; the Former Resembles a Twisted Ribbon and the Latter Is in the Form of Filaments

secure themselves on some rough surface, colonize, multiply and grow on the outside of their own dead bodies and colonies, thus building up a formation nodular in character and of concentric layers.

In view of the fact that the physical and chemical properties of the tubercle are so similar to limonite and bog-ore, and that both are hydrated magnetic oxides of iron, and that it is known that bog-ore is formed largely

Map Showing Areas Where Tuberculation Is Known to Exist in Varying Degrees

by bacteria, the view that tubercles are caused by bacteria seems tenable.

A few words in passing regarding one of the specimens of pipe removed from Philadelphia would not be out of order. This 9 ft. length of cast iron pipe was laid under Broad Street, Philadelphia, in the year 1819. During excavations for the South Broad Street subway in 1926, it was necessary to remove certain portions of this pipe line which had been in service continually since the date of installation. This pipe having served the city of Philadelphia for over 100 years and being still in excellent condition naturally had considerable scientific and historic as well as advertising value. While

Plate 5—Gallionella—Resembling a Twisted Hairpin Whose Open Portions Become Filled with Oxide of Iron

the interior of the pipe was affected somewhat from tuberculation, the condition was not serious.

Upon examining tubercles from all of the locations mentioned heretofore, the authors found three of the higher bacteria known to be potent factors in the formation of bog ore. At the same time there were found three other ordinary bacteria which collect iron. These bacteria may be seen on Plate 1, which is a photograph of a petri dish containing iron bearing agar in which the colonies are growing. It was later proven that these organisms grow also on media which contains little or no iron. This supports our contention that iron is not necessary to the growth of either the higher bacteria or of the ordinary bacteria which are iron gatherers. When we say they do not need iron to grow, we mean that none of the materials used in making the media contained iron, except the minute traces which might be found in the agar or the gelatin, etc., and that the growths showed no iron colorations whatsoever.

In the case of the pipe from Falmouth, Mass., Plate 2 shows a pipe which was entirely closed. You will notice the amount of iron ore which came out of this pipe, yet the pipe itself is scarcely attacked and the coating was still intact in a large part of the internal area. Plate 3 shows tubercles taken from this pipe, the iron oxide being gathered for the most part from the water by micro-organisms.

These iron mongers have also been found in an open spring near Burlington, N. J., wherein all the rocks were covered with a deposit of iron oxide. We made an agar stab of this water and succeeded in growing Leptothrix, Gallionella and the Spirophyllum. Plate 4 shows Spirophyllum and Lepthothrix. The Leptothrix are shown as long filaments and those which resemble a twisted ribbon are the Spirophyllum. Plate 5 shows the Gallionella which resembles a twisted hairpin wherein the open portions of the twist become filled up with the collection of iron oxide. The ordinary bacteria of which we have been speaking and which we have watched collect iron are all aerobic and liquefying. Other characteristics such as flagellae spores and bacteriological identification reactions are omitted as of no interest except to the bacteriologists.

In conclusion, it is our belief that both the higher bacteria and the lower forms were instrumental in the formation of bog-ore deposits in South Jersey and other localities and are identical to those which we have shown to exist in the specimens examined. We feel, therefore, that a problem of the greatest importance is herewith presented to the bacteriologist. How best to treat the water supplies of this country in localities where tuberculation is prevalent in order to destroy these various micro-organisms or to prevent colonization is an important problem.

From the evidence available it is apparent that tuberculation may set in without corrosion of the pipe being noted—this provided that the iron gathering bacteria may get their iron from the water which is flowing through the pipe.

If these bacteria can find a minute spot of bare iron, where the localized iron concentration is high, they will accumulate rapidly on such spots and their precipitation of iron will be augmented. A rough interior pipe surface or projections on the inside of the pipe will greatly aid these bacteria in securing a hold on the pipe wall and increase their rate of colonization. Under either of these conditions, the bacteria will multiply rapidly, if there is sufficient organic matter in the water to furnish sufficient food.

When once these organisms secure a footing, they colonize and build up a tubercle the rapidity of which depends upon the amount of suitable food and whether there is sufficient iron in a medium with a suitable pH value. A slightly acid medium (pH under 7) is most favorable to their development.

Inasmuch as castings coated by the dipping process have many minute pinpoint holes and consequently many spots of bare iron as can be demonstrated by the ferroxseyl test, pipe with such coatings offer a fine field for the colonization of iron gathering bacteria, although not as suitable a field as is found in an undipped pipe. This is the reason that pipes require lining by methods other than dipping if tuberculation is to be prevented by the protective coating alone. Several types of linings are available which are quite satisfactory for preventing tuberculation. Among the linings in common use are cement and bitumastic enamel. Linings should be applied centrifugally to give an even and homogenous protective cover to the surface of the iron and thus secure a surface so perfect that any iron bearing bacteria present in the water supply cannot readily find a lodging place where contact is made with the bare iron.

The surface of the cement lining exhibits an alkaline condition and we find this an important factor in the retarding of the growth of these bacteria. Our investigations to date have lead us to believe that an iron bearing water low in content of organic matter and possessing an alkaline reaction will not tuberculate. On the other hand, a water containing iron and having a

high organic content will readily tuberculate if there is a slightly acid condition present. It can therefore be seen just how important the alkalinity of the cement lining of the pipe becomes for in this case the medium completely covering the inside of the pipe at the same time creates a chemical condition most discouraging to the formation of tubercles.

As an added point of interest we present, herewith, for your information a map of the United States upon which we have indicated areas where tuberculation is known to exist in varying degrees. This map was prepared on the basis of the information obtained from a questionnaire sent to waterworks companies throughout the United States by the Sectional Committee on Specifications for Cast Iron Pipe. We also give, herewith, the key for diagnosing this map:

KEY TO MAP	SOURCE OF SUPPLY
x No tuberculation	R—River
o Moderate tuberculation	L—Lake
⊕ Severe tuberculation	W—Wells
	S—Springs
	I—Impounded

For instance, we find that at Charleston, S. C., the water supply is derived from a surface with a low pH value and having a high organic content. Severe tuberculation took place at Charleston necessitating the cleaning of the distribution mains several times. Milk of lime was first used in an attempt to raise the alkalinity but brought objections from householders. Caustic soda was then used and it was found by doing so that the CO_2 content could be brought to zero if desired and the pH value maintained at any desired figure. Furthermore, this addition of soda softened the water.

It is interesting to note that J. E. Gibson, Manager and Engineer of the Charleston Water Department has published statements to the following effect: "The Department feels that with the combination of the new method of treatment of the water and the cement lining of cast iron mains it has materially overcome its difficulties."

Editor's Note—Elsewhere in this issue is published an account of the New England Water Works Association meeting which includes notes taken during discussion of the above paper.

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Cast Iron Pipe Still In Use at Boston, Mass., After 83 Years of Continuous Service

A ceremony of historical and economic interest took place in Boston during the recent 50th Annual Convention of the New England Water Works Association.

On Sept. 30th, a portion of one of the earliest laid cast-iron mains in America was uncovered on the Boston Common near Frog Pond.

Accompanying photographs show one section of the pipe 9 ft. in length and 30 in. diameter. No further description of the condition of this pipe is required. The pipe was manufactured in Scotland for the City of Boston and it is still performing its function efficiently after 83 years of continuous service.

Of the ceremonies marking the turning in of the new water supply in 1848 the following is recorded as having taken place.

When the new cast iron pipe water line from Lake Cochituate was opened on Oct. 25, 1848, a public holiday was declared. A salute of 100 guns was fired—church bells rang—school children formed part of a great procession that marched through the streets of Boston to the Common where an ode written by James Russell Lowell was sung by the children. At the conclusion of the singing the Mayor opened a water gate and a column of water 6 in. in diameter spurted 80 ft. into the air from a cast iron pipe.

The ceremony at the recovering of the pipe on Sept. 30, 1931, included the playing of the same band music that marked the laying of the pipe 85 years previously—"Hail Columbia" and "Adams and Liberty."

Mayor James M. Curley made an address which was broadcast at noon from Boston Common over Station WEEI and used the very same shovel to put back the first shovelful of earth as was used on Aug. 20, 1846, when Mayor Josiah Quincy and former President John Quincy Adams officiated at the breaking of ground for the first cast iron pipe line which would supply the City of Boston with water.

Cast Iron Pipe Which Has Been in Service in Boston Continuously Since 1848. It is a Scotch Pipe, Imported for Laying in 1846; 9 ft. Lengths, 30 In. Diameter; Uncovered Sept. 30, 1931, for Inspection

Recovering Ceremony: Mayor Curley Using the Original Shovel Used on Aug. 20, 1846, by Mayor Quincy and ex-President Adams. George H. Finneran, of Boston, Former President New England Water Works Association Is Standing Next to Mayor Curley

SYMPOSIUM OF PRACTICE

METHODS AND COSTS OF THAWING OUT SERVICE PIPES

Lansford, Pa.

It is only during an unusually cold winter with light snowfall which permits the frost to penetrate to an unusual depth that we experience any trouble from frozen service pipes. This condition has occurred twice in the past ten years. The service pipes are laid 3½ ft. below the surface which efficiently protects them. Those that are frozen we find were installed many years ago at lesser depths. Subsequent to the freezing of a service pipe, during the following summer, we lower it to the proper depth to prevent a repetition of this condition. In view of these conditions we find it more economical to employ the local light company to thaw out such pipes as are frozen. Depending upon the extent of the freezing, and therefore, the quantity of power consumed, the cost per service line amounts to from $10 to $15. Service in this way is promptly resumed.—Geo. M. Roads, Jr., Superintendent, Panther Valley Water Co.

Albany, Ore.

The Mountain States Power Co. uses a thawing transformer for thawing out service pipes. We have found that a low voltage transformer with high reactance takes care of this work very nicely.—G. McClellan, General Superintendent, Mountain States Power Co.

Stratford, Ont.

In Stratford we are not seriously affected by frost in services and mains, but have the following equipment purchased some years ago: A 10 K.V.A. transformer with a 2200 volt primary and a range of 12½ to 100 volt secondary. This equipment is rapid and does the work well. It is, however, cumbersome and must be handled carefully on account of the high voltage. More recent equipment of the same nature is now available and no doubt more satisfactory. We also use a small steaming device which has proved satisfactory on services.—A. B. Manson, General Manager, Public Utility Commission.

Appleton, Wis.

We do not have any equipment for thawing out services and find it cheaper to have the local power company do the work for us. They rig up a transformer on a truck and have a couple of their men do the work. They cut in on their power lines near the frozen pipe and attach one wire to service in basement and one to a nearby hydrant. Then the current is turned on and in a few minutes the service is thawed out. We have found the use of electricity in thawing services to be cheapest and requiring least labor.—A. E. Dimick, Assistant Secretary, Appleton Water Commission.

Montreal, Que.

For thawing out frozen service pipes we use electricity entirely. We have found this method quite satisfactory and much more expeditious and economical than the old methods of digging to the pipe then cutting, tubing and thawing the pipe with the use of hot water or steam. The city water department has three gasoline engine driven electric generator units. These outfits with the necessary copper cable conductors to attach to the pipe, are mounted on a truck or sleigh for the winter and are sent out where required. Our services are generally all laid below the frost line, so that when frozen services are reported the trouble is usually to be found inside the property line. We charge $5 for thawing a service, this amount has to be put on deposit with each application for thawing, and if the service is found frozen in the street, outside the property line, no charge is made, and the amount deposited is returned to the applicant.—T. W. Lesage, Engineer, Canalization Department.

Shawinigan Falls, Que.

We have no apparatus of our own to thaw service pipes. The Shawinigan Water & Power Co. has a portable electric equipment to do this work and they charge us $5 to thaw a service pipe.—Narcisse J. A. Vermelt, City Manager.

St. Paul, Minn.

Several years ago the St. Paul water department began thawing frozen service pipes or water mains by the use of electricity. For that purpose we use at the present time one 20 K.W. 650 amp. 45 volt, Roth Brothers generator, direct connected to a 50 H.P. Wisconsin motor, 900 R.P.M. This equipment in the fall is mounted on a truck which is kept in readiness at all times to respond to emergency calls as they may come in, which, some winters, happens very frequently. This method of thawing pipes is very successful and in as far as I know, the best and most practical method now being used by water works men throughout the country. A number of machines of similar type are on the market and I presume all of them are securing good results. The method of procedure is to carry a long line of cable some 500 or 600 ft. in length, hooking one end of the circuit to the water pipes in the house, usually in the basement, and the other end to a fire hydrant. A similar method is used in thawing water mains except, of course, in that case it is necessary to make one or more excavations, attaching one end of the cable to the water pipe and the other end to the fire hydrant. House service pipes are usually thawed out in 10 or 15 minutes' time, but we have on occasion required five or six hours to thaw out a water main 6 in. in diameter.—Wm. N. Carey, Chief Engineer, Department of Public Works.

Ottawa, Ont.

In 1919 the writer designed an apparatus for thawing out cast iron mains and water services. The apparatus is a self contained power plant generating electric current of sufficient capacity at the required voltage to thaw pipes ranging in size from ½ in. to 6 in. in diameter. During the period 1919 to 1930 the city has constructed three complete machines which have given excellent results. In the city of Ottawa to date 5393

Electric Thawing Apparatus of Ottawa, Ont.

services have been thawed out at a cost of $1.78 each. The following result is an average case taken from over 5000 services thawed out in the city of Ottawa from 1919 to 1930, inclusive: Average length, 75 ft.; Average size, ⅝ in. lead pipe; time, 1 minute 40 seconds.—W. E. MacDonald, Water Works Engineer, Water Department.

Menasha, Wis.

We are also an electric utility and do not have any regular pipe thawing outfit complete ready to use. We do however have a lot of miscellaneous cable and special fittings of our own make that we can attach to hydrants or services as the case may be. Whenever necessary to thaw any frozen lines we use two 10 K.V.A. single phase 2300 volt primary 230-115 volt secondary transformers, primary connected in series and secondaries in parallel thus giving us 57½ volts on the secondaries while they are connected to the frozen lines. It only requires a few seconds as a rule and water starts to flow.—J. H. Kuester, superintendent, Electric and Water Department.

Islington, Ont.

It has been our practice to dig up services which have become frozen, lowering the same with a view to eliminating the cause of the freeze-up. By so doing, we have cut down the percentage of frozen services to about 1/15 of 1 per cent annually. Whenever a frozen service is encountered, where it is deemed unadvisable to dig up, we rent an electric thawing apparatus from the town of New Toronto. This apparatus although somewhat balky to move around, has proved very satisfactory.—W. H. Walker, Township Engineer.

Ely, Minn.

For service lines of the ¾ in. size we use a 15 K.V.A. transformer, and a reactance coil built by the Westinghouse Co. This coil is connected in series with the transformer. This apparatus has given very good results. We have thawed 6 in. mains with this coil and a 30 K.V.A. transformer. Our primary voltage is 2300.—Wm. Mitchell, Superintendent, Light and Water Department.

Toronto, Ont.

Practically all our water services are installed at a depth of 6 ft., and on that account we have very little trouble from frost. Our experience, therefore, in connection with the best methods of thawing water services is limited. When we do have a service to thaw out, we usually have the work done by the local hydro-electric company who have equipment for the purpose.—Geo. G. Routledge, Engineer in Charge, Water Distribution Section.

Utica, N. Y.

In our city the service pipes are owned and maintained by the property owners. We have, therefore, had very little experience with thawing frozen services. The method generally used by the property owners is to have the service pipe thawed by electricity, the work being done by the local electric company. This method seems to be satisfactory.—J. T. Robertson, Engineer, Consolidated Water Co.

Rochester, N. Y.

We have comparatively little trouble with frozen service pipes. However, when a service is frozen we require the consumer or owner of the service to sign an application agreeing to pay all expenses connected with the work of thawing the service. A copy of the form follows:

.....193.....

I hereby agree to bear all expenses connected with the work of thawing out my service pipe at No.....St.

The work to be done by the Rochester Gas & Electric Corporation.

.....

Owner.

Per: .....

Send bill to:.....

No.....

The actual work of thawing is done by electricity by the local gas and electric corporation and upon receipt of their bill for this service the city pays it and immediately bills and collects the amount from the owner of the service. The Water Bureau disconnects the meter while the service is being thawed out and replaces it upon completion of the work but for this no charge is made.—I. E. Matthews, Superintendent of Water.

Fort Atkinson, Wis.

We have no special apparatus for thawing services but ordinarily use a stock transformer of from 10 to 25 K.W. capacity, depending upon the nature and size of service to be thawed. As we operate the electric utility in Fort Atkinson for our own company as well as the water utility for the city, the necessary electric apparatus is always available. It is customary to mount a 2300 V. transformer on the rear of a truck together with a salt water barrel for resistance in secondary, and place truck at nearest pole available at customer's premise, running primary wires to transformer on truck and secondary of 120 V. through resistance to customer's end of frozen surface with opposite side of 120 V. hooked on at hydrant or neighboring customer's service. We are using, then, a stock transformer of 2300 V. of 20-1 ratio with 120 V. on frozen surface through salt water resistance.—W. D. Leonard, District Manager, Wisconsin Gas & Electric Company.

Luncheon Is Served. Members as Guests of the City of Boston Lunch at Historic Wayside Inn at Sudbury

50TH ANNUAL CONVENTION OF THE NEW ENGLAND WATER WORKS ASSOCIATION

ORGANIZED in 1882, the New England Water Works Association is but one year younger than the American Water Works Association. Starting with 28 charter members there were in June of this year 830 members.

The 1931 convention, held in Boston, Sept. 29th through Oct. 2nd, is recognized as the best meeting yet held with well over 500 registrants. The meeting was called to order by President Geo. H. Finneran and then followed a most excellent program arranged by the Program Committee headed by E. Sherman Chase. The Entertainment Committee, over which Burt B. Hodgman continues to preside with customary ability, left nothing to be desired.

On the last day a tour of inspection of the reservoirs, pumping stations and chlorination stations of the Boston Metropolitan District water supply was arranged for. An interesting phase of this trip was the stop for luncheon at the Old Wayside Inn near Sudbury, Mass., which now is the property of Mr. Henry Ford. Together with a picturesque overshot water-wheel grist mill and a little red schoolhouse on the 3000 acres purchased by Mr. Ford, this historical stage coach stop is being preserved for the benefit of future generations.

Medal Award.—The Dexter Brockett Memorial Medal awarded for outstanding papers read before the Association during the year previous was presented to Dr. Frank E. Hale, Director Laboratories, New York City Department of Water Supply for his paper on "Control of Microscopic Organisms in Public Water Supplies"—already published in the Journal of the association.

Historical Papers.—Papers presented on the first day covered the historical side of the association, the Boston Water Works and the trend of water works practice during the past 50 years. The authors of these were respectively, Chas. W. Sherman, of Boston, Frank A. McInnes of Boston, and Caleb M. Saville of Hartford, Conn.

Superintendents' Day

With W. A. MacKenzie, Superintendent Water Works, Wallingford, Conn., presiding in the forenoon the subject covered was "Emergency Problems of the Water Works Superintendent."

"Chlorination for Special and Emergency Purposes."—J. D. MacMahon, pointed out the need of advanced preparations to provide temporary, or if already chlorinating, then additional chlorination capacity for use in emergencies. Especially useful is a recently developed high test hypochlorite carrying twice the chlorine content of ordinary chlorinated lime and a product which keeps well and is readily soluble in water. The equipment required is not elaborate nor expensive and a supply of this chlorine carrier can be kept on hand for emergency uses such as existed recently on the Boston water supply. This new material was fed from solution tanks during periods of temporary need of greater chlorinating capacity than the chlorinators could provide. A solution containing 1 per cent (10,000 p.p.m.) available chlorine was entirely satisfactory and the use of an even stronger solution is practicable if necessary.

High test hypochlorite has been employed to treat the entire flow of streams entering reservoirs and small sewage plant effluents. For conveying the solution ordinary iron piping may be employed and wooden or concrete solution tanks are satisfactory.

For algae control this hypochlorite powder has been successfully employed by sprinkling it dry on the surface and around the shoreline of reservoirs. At Boston it has been applied to an aqueduct for destruction and inhibition of pipe moss—the dosage employed being between 0.3 and 0.55 p.p.m. of available chlorine over a period of 24-hour continuous application twice monthly. The higher dosage produced residual chlorine at the end of the 1 hour travel through the aqueduct treated.

To clean the sand beds in dirty filters high test hypochlorite is applied dry over the filter surface in a proportion of 4 lb. per 100 sq. ft. of filter area. When applying, the filter is out of service with roughly 1 ft. of water above the sand. After applying the hypochlorite by broadcasting over the filter surface the water level is lowered just to the sand surface. After 12 to 24 hours standing the filter is washed thoroughly and returned to service. In certain stubborn cases where the sand grains are not freed of the organic coating by this treatment alone caustic soda is added along with the hypochlorite to secure 2 per cent caustic by weight in the foot depth of water treated, i. e.—17 lb. per 100 sq. ft. filter surface.

"Sterilization of New Mains or Old Mains After Repairs."—Experiences in disinfection of mains was covered by Harry Fuller, Superintendent Water Works, Portland, Me., in which he pointed out that the practice at Portland was to use chlorinated lime or hypochlorite on the smaller mains and liquid chlorine for the large mains. About one ounce, or about a teaspoonful, of chlorinated lime is placed in each length of small pipe during laying. Where the pipe is upgrade water is admitted at the low points to fill the main and thus avoid washing the powder entirely to one end. After filling and standing 24 hours the line is bled and samples of water taken for analysis before placing in service.

For sterilization of long lines of large pipe a portable chlorinator is employed. The line is filled at a rate to provide a strong test for free chlorine at the far end. Where dry chlorine gas must be used solution in the water is secured by admitting the chlorine gas to a section of 8 in. pipe used in filling the mains. A valve on each side of the chlorine inlet is partially opened to create turbulent flow between the valves and provide as nearly complete solution of the gaseous chlorine as possible. After the first chlorination and flushing it is often necessary to provide a second treatment. Small

E. Sherman Chase of the Firm of Metcalf & Eddy, Taking a Few Himself

"Gil" Pratt, Division Manager, Wallace and Tiernan Co. A New Englander, First, Last and Always

mains are first thoroughly flushed and large ones are brushed out before chlorinating. The speaker believed from his experience that it is highly important that all new mains should be thoroughly flushed and heavily chlorinated.

MR. GRISWOLD of the Hartford Water Department, gave his experiences in main sterilization in which the importance of flushing in all directions after sterilization was important. Otherwise some heavily chlorinated water reaches consumers and causes complaints. Mr. Griswold prefers chlorinated lime for short lines but liquid chlorine more practical for long lines. It was brought out in discussion that frequently 250 parts per million of chlorine was applied to the filling water in order to secure absolute disinfection without delay and it was also indicated that best practice called for pumping in chlorinated lime solution at the end of the job rather than addition of the powder as the pipe is being laid. After pumping in the solution through a corporation cock the line is filled and tests made at the far end for free chlorine. On the whole, liquid chlorine and a portable chlorinator appeared most universally satisfactory for main sterilization except for very short lines. Adequate pre-cleansing of the line was also stressed in the discussion.

"Preparation for, and Action in Emergencies" was the topic covered by WARREN J. SCOTT, Chief Engineer, Connecticut Department of Health. Among the most serious aspects of water supply is frequently the absolute lack of an existing supply which might be introduced into systems during emergencies. The need for preparation of plans to secure an emergency supply in advance of the emergency was stressed and he remarked that city authorities do not sufficiently appreciate the importance of so doing and therefore the superintendent or manager is frequently not allowed the necessary funds for such preparedness procedures and that this was a serious mistake.

Several important instances of what has happened in emergencies effecting Connecticut water supply systems were cited with examples of assistance procurable from the Engineering Division of the Department of Health which also maintains two emergency chlorinators for immediate loan where necessary. Duplicate chlorination equipment should be provided where chlorination is required and both chlorinators kept in operation by changing from one to the other or splitting the dosage between them and thus both kept operating. Idle chlorinators deteriorate. In lieu of duplicate chlorinators a supply of hypochlorite such as described by the previous speaker should be kept in stock for emergency use.

Tastes and odors in water supplies are becoming less excusable and when an emergency of this nature is met the superintendent should be prepared by first familiarizing himself with the available methods such as ammoniation or activated carbon application now used successfully to eliminate taste troubles. Algae control methods should be understod and practiced to avoid as far as possible emergencies caused by taste and odor occurrences. Where these difficulties do occur the State Health Department stands ready to assist when requested.

In particular the chance of failure in purification methods is most liable to happen in the Spring when during the thawing periods careful operation will preclude an emergency. Residual chlorine tests should be made frequently and accurate records of this and the bacterial quality of the water kept.

MR. GRISWOLD of Hartford, Conn., in discussion spoke of emergency preparations at the slow sand filter plant which included two automatic chlorinators operated once weekly and also two manually controlled

Dr. Frank E. Hale, Dexter Brockett Medalist, 1931, with Mrs. Hale

chlorinators located to treat the water leaving the reservoir.

"Meeting Emergencies Resulting from Breaks in Mains."—THEODORE BRISTOL of Ansonia, Conn., outlined his ideas of procedure for minimizing troubles in case of water main breaks which included recommendations that all important gate valves should be operated at least once yearly and be kept in good working order; that charts be carried in trouble wagons to show accurately the valve locations; that telephones be installed in houses of all foremen and that a list of the industrial plants dependent upon the supply be kept and that these be promptly notified of a shut off or main break.

W. H. MacKenzie of Wallingford, Conn., recounted experiences where a gate failure without replacement in stock created serious difficulties which could have been avoided by carrying important replacement stock.

S. H. MacKenzie of Southington, Conn., stressed the desirability of providing duplicate supply mains from the source of supply to the distribution system and speaking from experience believed that two smaller mains were preferable to one large main. In addition to less liability of supply failure there were other advantages. Flushing the lines and cleaning the mains

Chlorination Station on the Western Aqueduct of the Boston Water Supply; One of Three Such Stations

was made simple where such duplication existed and considerable expense was saved during cleaning by having frequent blow-offs in the 8000 ft. mains to town —the main cleaner traveling through twice in a period of two hours.

For an emergency supply experience has indicated the desirability of a standby well located on the side of town opposite from that which is nearest the source of the regular supply. Once he had the distribution system actually cut in two for necessary repairs which was possible only because of the existence of the well used to supply the side of town which otherwise would have been without water during the emergency.

Concerning gates on fire hydrants, he believed they should be located as far away from the hydrant as was practicable, and concerning house service pipe, he thought 1 in. should be the minimum size allowed. Mr. MacKenzie related experiences with successful clearing of house service pipes by pumping candy gumdrops through from the cellars into the mains and had found it very practical. Why his men preferred the green ones rather than drops with other colors he was not prepared to explain.

"Tuberculation of Mains as Affected by Bacteria."—Dr. H. G. Reddick and S. E. Linderman, pointed out quite conclusively that tuberculation of mains or pipes made of steel and iron may be, and is frequently due to biological phenomena and can be controlled by sterilization of the water, by maintaining a high alkalinity or by eliminating the iron content or the bacterial food supply from the water. Of these the first two seem the most practicable measures for correction.

Tuberculation it seems can proceed without simultaneous corrosive action on the metal surface and does not take place actually on top of unbroken protective coatings in many instances. Cement lined pipe is not tuberculated because the metal is completely protected and no iron is dissolved to supply the bacteria which are capable of depositing iron tubercules, and also more probably because of the alkaline nature of the cement surface which prevents the organisms from injesting iron from the water and depositing it in the form of hydrous ferric oxide nodules.

These organisms which include Leptothryx, Spyrophyllum, and Crenothrix require a medium more acidic than pH 7 to function and they have been isolated from iron ore deposits and springs which naturally contain some iron in solution and considerable oxide of iron deposited in situ by them. In alkaline waters these "ironmongers" are dormant but become active if the alkalinity be lowered by some treatment process or by taking up carbon dioxide. If the water naturally contains dissolved iron pipe coating other than cement may not prevent tubercule depositions. If the water is freed of its soluble iron and sterilized thoroughly or alkalinized to raise its pH value sufficiently the tuberculation caused by these living organisms can be eliminated.

This new and interesting topic is more adequately covered in a condensed paper prepared by the authors for Water Works and Sewerage which appears in full elsewhere in this issue.

In the ensuing discussions of the above paper it was brought out by J. T. Robertson that at Utica, N. Y., tuberculation had been pronounced and that since the first cleaning of the supply mains from the reservoir to town cleanings every 18 months had been required to keep up the capacity of the mains to a point where the factor $C = 120$ in Kutter's formula.

In reply to a question the authors did not believe it requisite to paint the inside of cement lined pipes to protect the cement and Mr. Estes of Danforth, Conn., reported a very old cement lined pipe examined by himself had only a slight slime coating. When rubbed off the cement surface was about like fine sandpaper. The

E. C. Craig, Superintendent, Providence, R. I., Water Works and the "Missus"

cement had not been attacked more than 1/64 in. at the most.

Malcolm Pirnie, Consulting Engineer, commenting on the Utica, pipe line 12 miles long and 24 in. in diameter stated that the tuberculation taking place in summer caused the main to act as an efficient iron removal plant. The iron in the water at the intake was being removed at one time to such an extent that between 9 and 12 tons of iron per year were deposited in the pipe line proper during the 12-mile water travel. By taking the water from a reservoir level which contained less iron the depositions had been reduced to 1 ton per year. This he said indicated not only the importance of biological and other effects which cause

iron deposition in mains but also indicated the importance of intake arrangements in reservoirs which would allow draught from a selected water depth between the near surface where algae predominates and the depths at which the iron and manganese contents become important factors.

MR. MACKENZIE reported greater tuberculation where velocity of flow had been greatest, which the authors ascribed to the greater total weight of iron passing through in the increased flow and consequent increased deposition by the organisms.

D. A. HEFFERMAN of Milton, Mass., a superintendent of long experience advocated use of cement lining for all pipes under 6 in diameter.

C. W. SHERMAN, Consulting Engineer, reported that he had examined a 17 in. pipe constructed of wrought iron sheets riveted which had been covered and lined with Rosendale cement (1 cement; 2 sand) that had been laid in 1887. The outside cement crumbled away but the lining and interior of pipe was in excellent condition. The lining could, however, be scraped away with a sharp instrument.

One member reported cement lined pipe which had not given trouble after 85 years of service and the water is very soft.

It was brought out by W. A. MACKENZIE, of Wallingford, Conn., that red brass piping for house services had been very satisfactory for at least 20 years in certain instances but that it was important to specify a copper content not less than 85 per cent. It was further indicated that ordinary brass pipe would not resist corrosion and particularly where free carbon dioxide and bicarbonate of soda was present.

MR. ARNOLD of Providence reported the use of 30,000 ft. of red brass service pipe with satisfactory results but suggested that in the final analysis a chemists' opinion should be sought when a decision had to be made in selecting pipe materials. After all he had concluded that the quality of the water in combination with other matters would be the deciding element and that a chemist should be consulted before drawing conclusions or experimenting. The discussion closed with these remarks.

THE RELATION OF WATER WORKS TO FIRE FIGHTING

The symposium on the subject of the "Relation of Water Works to Fire Fighting" was presided over by S. H. Taylor, Superintendent of Water Works, New Bedford, Mass. The introductory paper by C. W. Mowry of the Associated Factory Mutual Fire Insurance Companies, as reported below represents the most complete paper on this topic yet developed and will be printed in full in a subsequent issue of WATER WORKS AND SEWERAGE.

"Water Consumption During Fires."—MR. MOWRY stressed the factors which govern the quantity of water required for fighting any fire as being composed of three items, viz.: how promptly water is applied, where applied and how applied. Most fires are quickly extinguished by hand or by sprinkler systems. Nowadays with excellent roads and automotive rather than horse-drawn equipment large fire pumper capacity can be concentrated quickly which has a great influence on the need for larger water mains and storage. While the fire requirement does not average more than 1 per cent of the total consumption, sudden demands during conflagrations require special planning of water systems and has resulted in the individual high pressure systems now in vogue. Mr. Mowry's paper contained extensive fire fighting data and records which show how nearly specifications and experience coincide. The highly specialized treatment of the subject warrants future publication of the paper in full rather than an attempt to cover it in this resume.

R. S. Scott, Consulting Engineer with Nicholas S. Hill, and Stuart A. Knox of the Same Firm

J. E. Longley of Lock Joint Pipe Co.

Stephen H. Taylor (Right), Superintendent, New Bedford, Mass. (Sorry We Missed Getting the Other Member's Name)

WALTER ACKERMAN of Fall River, Mass., in discussion brought out the fact that fire protection expense can be deducted from income taxes. Further that some fire protection expense should come from taxation and the balance from income from the sale of water. He points out that one private water company in a large city successfully collects standby charges from factories who install sprinkler systems. He believes that all hydrants should be gated and that the pressure type hydrant is preferable to others in order to prevent break losses.

J. W. GRAHAM of Portland, Maine, brought up the subject of having a universal method of hydrant marking by standardized painting. The Water Utilities Commission of Maine has proposed definite color schemes to indicate the different capacities of the hydrants so that the firemen will know what to expect from the hydrant when arriving on the scene of the fire.

C. M. SAVILLE of Hartford, Conn., ventured the suggestion that fire protection might well be considered as an insurance that factories, etc., would not be shut down because of fire damage and therefore constituted insurance against losses to the city and individuals employed. This reasoning, he said, would then argue that fire protection might with justification be wholly financed from taxation. Small consumers should not pay for fire protection which is out of all proportion with what they get. Taxpayers seldom pay their share for the fire protection they get. The usually small water consumption by large factories does not begin to pay for the cost of providing the fire protection demanded.

MR. MOWRY closed the discussion by remarking that factories, etc., with improper fire equipment of their own make large demands on the city system for adequate protection. On the other hand there are others that provide their own fire protection system and make less demands on the city. It was his opinion that the company which demanded the most should pay accordingly, which is not now the case.

High Pressure Fire System Demonstration.—Following the symposium on fire protection, the Boston Fire Department put on a demonstration of fire fighting equipment which was very effective. In this there were 14 hose streams in operation from the high service mains throwing water at a rate of 43,000,000 gal. per day. In addition two fire boats were giving a display, throwing 12 hose streams. Fire Commissioner E. F. McLaughlin was present and Superintendent of Maintenance Williamson of the Department described the high pressure fire system and the operations. Floodlighting during the display was very effective as was the control of operations by radioed orders to the boats and through headquarters.

E. L. Bean, Chief Chemist, Department of Water Supply, Providence, R. I.

E. Sherman Chase, Vice President, New England Water Works Association, at the Old Pump at Wayside Inn, Sudbury, Mass.

SYMPOSIUM ON WATER PURIFICATION

ROBERT SPURR WESTON of Boston opened the symposium with a paper dealing with *"The Beginnings of Water Purification,"* in which historical developments were covered from the earliest filtration system installed at Chelsea, England, in 1829 up to the present.

"Operating Experiences at the Cambridge, Mass., Filtration Plant" were given in a paper by M. C. WHIPPLE and F. E. SMITH, in which it was pointed out that the coagulating basin capacity of 2.5 hours retention had proven deficient for handling the soft, organically colored water which had to be dealt with. The maximum color during the past year had been only 80 parts per million. The "fresh" coloring matter resists coagulation and fine floc passes the filters at times.

The use of sodium aluminate with aluminum sulphate had not improved conditions and neither had prechlorination which, however, had been applied so as to secure little or no contact of chlorine with the water prior to coagulant addition.

The Wheeler type of filter bottoms employing concrete balls had proven entirely satisfactory and due to loss of fine sand the effective size of sand had increased since 1923 from 0.38 mm. to 0.51 mm., which had also resulted in less troubles in recent years from sand shrinkage, cracks, etc.

Wash water recovery at the plant had not been a success because of taste production and increased filter loadings caused by return of wash water to the coagulation basin influent.

The algae Synura had caused taste troubles when present in the reservoir in as low concentration as 4 to 7 standard units. Difficulty from Leptothrix growths clogging the alum solution lines had been connected by adding chlorinated lime to the alum solution tank once weekly.

For corrosion correction soda ash has been replaced by lime because brass piping began to show signs of corrosion. Since the use of lime added to the filtered water to produce a pH value 8.4 + (5 to 10 p.p.m. $CaCO_3$) requiring 50 to 125 lb. hydrated lime per million gallons relief from brass corrosion had been observed.

Operating costs have been reduced from $11.29 per million gallons to $9.07, most of which had resulted from care in chemical control and replacement of soda ash by lime.

"Five Years Water Purification at Providence" was covered in a most ably presented paper by E. L. BEAN, Chemist in Charge of the Providence filter plant.

Mr. Bean has to deal with an impounded water which is very soft and at times highly colored. The removal of iron, manganese and color at one operation presents serious difficulties. The filtered water prior to lime application which had produced considerable corrosion difficulties, and manganese deposits in the aqueduct and mains also represented a major difficulty which now appears to have been solved by a radical departure from the orthodox methods of treating soft colored waters.

In the new treatment, alum has been replaced by ferrous sulphate application to the raw water prior to aeration. Lime addition follows the aeration, being introduced ahead of the circular mixing chamber. Prechlorination is practiced to assist in oxidizing the organic iron and results in more effective coagulation. The pH value of the coagulated water is sufficient to render the filter effluent non-corrosive and thus no further limitation of the final effluent is required. To secure a non-aggressive effluent a pH value of 9.5 or above is required.

The Providence aerators of the spiral nozzle type remove 70 per cent of the removable carbon dioxide. With the previous alum treatment followed by aeration of the filtered water, and lime application to the plant effluent beyond, the major difficulty encountered has been the subsequent precipitation of manganese, practically none of which was removed by alum coagulation and filtration. It is estimated that more than 10 tons of manganese dioxide has been deposited in the filtered water aqueduct and distribution system requiring removal by major flushing operations. Periodically complaints from laundries would be received because of manganese discoloration of linens. Except for the precipitation in the aqueduct there would doubtlessly have been more such complaints.

Treatment costs at the filter plant including all operating and chemical costs are comparatively low, i. e., less than $6.50 per million gallons.

"Water Filtration at Hartford Conn."—W. A. GENTNER described the construction and operation of the Hartford filter plant of the slow sand type producing an average output of 18.6 million gallons per day. Operating at average rates of 3.5 m.g.d. per acre of

filter bed having sand with an effective size of 0.29 mm. The bacterial reduction averages 94 per cent and color is reduced from 17 ppm. in the applied water to 10 ppm. in the effluent. Aeration precedes the filters and is considered of extreme value at times.

An interesting means of loosening the sand beds when clogged below surface with dirt was described. Well points were sunk into the bed to a point below the dirty sand strata and water discharged through to lift the sand and wash the affected areas.

To vary the rates of filtration an unique scheme has been devised. On the ends of the arms of the Simplex rate controllers buckets have been attached to replace the sliding weights. By operating valves on the control tables located on the operating floor, water can be added to the bucket or bled out at will. To change the weight on the control arm and thus the controller valve opening, it is only necessary to add or discharge water until the rate of flow indicator registers the desired setting of the individual controller. [The same principle is also applicable to controllers on rapid sand filters and has been successfully employed.—Ed.]

Ejectors employed for removing dirty sand from filters have been studied and a style having ⅝ in. diameter of jet nozzle and 1¼ in. throat diameter has given greatest efficiency and satisfaction on all scores. Sand is washed by using four Nichols machines using 100 gal. water per minute under 160 lb. pressure.

"Operation of the Greenwich, Conn., Filter Plant." —H. C. Chandler, Chemist in Charge, described operation of the Greenwich plant which also supplies Portchester and Rye, N. Y., delivering daily 8,000,000 gal. of water.

The Sacramento type aerator nozzles require 10 to 15 ft. head to pass 100 gal. per minute for effective aeration. The circular type mixing chambers employ paddles revolving twice per minute.

Some filter units have been supplied with sand from Cow Bay on Long Island Sound at low cost. The washing out of the fine sand has been simple, leaving a product in the beds having effective size 0.4 mm. and uniformity coefficient of 2.7 which has proven very satisfactory for Greenwich conditions.

Washing rates of 29 in. vertical rise per minute in Winter and 42 in. rise in Summer have been employed during the past year to secure sand bed expansion of 50 per cent. Between washings "bed-jolting" secured by opening wash valve for a short interval has proven helpful.

Manganese appears at times in the raw water to the extent of between 0.3 and 0.5 p.p.m. It is at such times necessary to change lime application from the filtered water to the influent to the filters whereupon about 66 per cent of the manganese is removed on or within the filters. Caustic soda treatment is given the filter beds as often as required to clean the slime from the sand grains.

Chlorinated copperas can be employed as the coagulant with very satisfactory results but without any saving in coagulant cost. The same applies to sodium aluminate. The alum requirement averages 1.4 grains per gallon.

Operating costs amount to $16.50 per million gallons which includes $5.50 per million for low lift pumping.

Suggested Plan for Unemployment Relief.—A committee composed of Malcolm Pirnie, Stephen H. Taylor and the president-elect, Geo. W. Brehm, offered an important resolution which includes a plan for relief of unemployment by executing extensions and construction of revenue producing public works. This resolution, adopted by the meeting, which appears in full elsewhere in this issue, proposes a program covering a 3-year period initiating $150,000,000 worth of construction work rather than an attempt to distribute $20,000,000 to the unemployed in the form of a "dole" which would be dissipated.

The Allocation of Interstate Waters for Water Supply

Over the symposium covering the allocation of interstate waters for water supply Harrison P. Eddy, Consulting Engineer of Boston, presided.

"The Law of Interstate Waters and Its Application in the Case of the Delaware River" was the topic covered in a masterful presentation by Thaddeus Merriman, Chief Engineer, Board of Water Supply, New York City, in which the recent case of New Jersey vs. New York and New York City was reviewed. The case in question decided the rights of the City of New York to take water from a tributary feeding the Delaware River, thus becoming an interstate matter. New Jersey contended that such withdrawal would prove damaging to her best interests.

In this case New York City pleaded for 600,000,000 gal. daily from a stream within New York State and representing 25 per cent of the drainage area of the Delaware River. New Jersey objected to any withdrawal. The case was heard before a Special Master appointed by the Supreme Court of the United States. His recommendation was that New York City be allowed 440,000,000 gal. per day, provided that sufficient storage reservoirs be constructed to hold water for release at low river stages, which storage capacity will be roughly 10 per cent more than originally contemplated by New York City. In addition, the court requires New York City to provide treatment of the sewage contributed to the Delaware by Port Jervis, N. Y., to offset the reduced dilution created by the taking of water.

Mr. Merriman stated that these allowances and requirements are satisfactory to New York City and also to Pennsylvania, the intervenor State in the case, which acted to protect its own interests.

One of the outstanding principles governing the case was, in Mr. Merriman's opinion, that lower riparian ownerships must realize future shareship with States above and, further, that decisions must not be made by a court based upon abstract or future possibilities, but that there must be indisputable evidence presented by the plaintiff in such cases. In the Delaware River case, of the eight objections filed by New Jersey, only two were given serious consideration, sanitation being of primary, and recreation of secondary importance.

In the Delaware River case 7000 pages of printed testimony were taken by the Master.

In discussion, H. C. Critchlow, who represented New Jersey in the case, stressed the principle of equitable division of interstate waters as against that of purely riparian rights. As he understood it, the decision was designed to serve the present and that requirements could be made for greater release of impounded water should future conditions justify it.

Morris Sherrard, Cons. Engr., Newark, N. J., held the opinion that the water asked for in the original compact would not have affected New Jersey water supplies, and further, that he could not understand why use of water from a stream should entail the requirement that sewage treatment be provided for cities below by the taker.

Major Ezra B. Whitman, Cons. Engr., Baltimore.

Md., who appeared for New Jersey, stated that in his opinion the most satisfactory means of handling matters concerning streams of large drainage area would be found in the establishment of commissions to study the uses and control of each large or important river.

PROF. H. K. BARROWS of the Massachusetts Institute of Technology, who appeared for New Jersey in the case, stated that the Master's decision limits the diversion to about one-third of the natural flow and is stated as being subject to trial. In his opinion, ultimately a very large storage with greater release will be required of New York.

"Diversion of Interstate Waters for Domestic Water Supply—Case of Connecticut vs. Massachusetts" was covered by FRANK E. WINDSOR, Chief Engineer, Metropolitan District Water Supply Commission, Boston.

The Metropolitan Commission proposed to take water from the Ware and the Swift Rivers in Massachusetts, to which Connecticut replied by asking injunction proceedings although the entire water flow from this drainage area represented but 3 per cent of the Connecticut River flow through Connecticut.

Other supplies in the Eastern and Northern part of Massachusetts had been rejected by experts on the score of inadequacy or unfitness.

The Master in the case held that the court, regardless of expert testimony in the case, could not close its eyes to public opinion when it became a matter of enforcing the use of a polluted river over which Massachusetts had no control above its boundaries as the source of supply; that drinking use is the highest use of water and further that there was nothing in fact to indicate any real damage by diversion of the Ware and Swift Rivers to the extent contemplated, and that injunction can not be granted on evidence indicating probable damages only.

In the Connecticut River case 2000 pages of printed testimony were taken by the Master.

In discussion H. P. EDDY stressed the soundness of the court's opinion concerning the rights of the people to the purest available water supply and, further, he also cited the opinion of Justice Holmes in reviewing the Master's recommendation in the Chicago lake diversion case in which Justice Holmes stated that even with 90 per cent purification of the sewage it is a surprise that the plaintiffs should want the effluent returned to the lake and that he commended the Master's decision allowing the diversion of lake waters.

X. H. GOODNOUGH, former Chief Engineer of the Massachusetts Department of Health, and intimately connected with the case and all that led up to it, remarked that in his belief cities must eventually go even to other states for water supply. Very large hydraulic power developments may make this feasible because of the low cost for pumping the water.

New Officers.—Reports of the tellers disclosed the following officers elected for the ensuing year: President—Geo. C. Brehm, Waltham, Mass.; vice-president—E. Sherman Chase, Boston, Mass.; secretary—Frank J. Gifford, Dedham, Mass.

ELECTRICAL INSTRUMENT FOR LOCATING GRAVEL BEDS.—The State Geological Survey of Illinois has been carrying on some experiments with an electrical instrument which may be useful in locating and outlining areas of water bearing sands and gravels beneath the surface. This instrument, called a "megger," measures the resistance to the flow of electricity through the soil and rock. Sand and gravel are located because they are more resistant than glacial clay.

Sanitation Projects for Unemployment Relief

At the recent conference of the state sanitary engineers at Montreal a committee composed of Ernst Boyce, H. J. Darcy, George H. Ferguson, L. S. Finch, R. E. Tarbett, A. D. Weston, W. L. Stevenson, chairman, submitted a report on the undertaking of sanitation projects for the relief of unemployment. The report stated in part:

"One of the major factors incident to the present economic crisis is the general inability to provide employment and find markets. It is essential that when industry is unable to employ workers, then official and voluntary relief agencies using public and private funds should provide work that will relieve such unemployment as far as practicable. The necessity for providing an outlet for productive labor on projects of public benefit is a problem that warrants careful consideration."

"Your committee believes that a reasonable share of such work could advantageously be done for the improvement of environment and the health of our people. Such constructive projects might include the improvement of water supplies and distributing systems, works for the collection and disposal of sewage, refuse, garbage and other municipal wastes, malaria and mosquito control, rural sanitation and reclamation of waste or wet lands for recreation and other useful purposes."

"State Health Departments should, during this emergency, insistently press for the accomplishment of construction or work really needed for the protection of the public health as such not only creates employment but takes advantage of the present low cost of construction and provides installations and results of permanent value useful to the community rather than mere temporary expediency. Furthermore, the great value in engaging the unemployed in useful work cannot be overemphasized."

"With these facts in mind your committee finally recommends that the necessary steps be taken to make surveys in each State of needed sanitary work in order to consummate such public health projects as will give useful work to the unemployed."

The report was adopted by the conference on Sept. 14 and subsequently was endorsed and approved by the Public Health Engineering Section, American Public Health Association and also by the Governing Council of the American Public Health Association.

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Engineers to Aid in Ending Depression

Plans to mobilize the nation's engineers behind President Hoover's program to end the depression are announced by the American Engineering Council. The aid of more than 100,000 engineers will be enlisted in a movement to increase and to stabilize employment, and to prevent the adoption of unwise legislation, Federal, state or municipal.

The Council will work with the relief organization set up by the President under the headship of Walter S. Gifford, president of the American Telephone & Telegraph Co., who is a member of the American Institute of Electrical Engineers. The aim, it was said, is not only to promote emergency measures but to develop sound permanent employment policies throughout American industry.

F. J. Chesterman of Pittsburgh, vice-president and general manager of the Bell Telephone Company of Pennsylvania, has been appointed chairman of a national committee to direct the engineering effort, which will be carried out in detail by committees to be named in every state. These committees will co-operate with the industries and with civic and business bodies.

Other members of the national committee are: General R. C. Marshall, Jr., of New York, who was in charge of the Construction Division of the War Department during the World War; E. K. Ruth, American Oak Leather Co., Cincinnati; W. R. Webster, Bridgeport Brass Co., Bridgeport, Conn.

PROGRAMS OF COMING CONVENTIONS

Ohio Conference on Sewage Treatment

The Fifth Annual meeting of the Ohio Conference on Sewage Treatment held under the auspices of the State Department of Health convened this year on October 13th and 14th at Akron, Ohio, At the time this issue of WATER WORKS AND SEWERAGE was going to press.

The November issue will contain a report covering the meeting. The program follows:

Tuesday, October 13

1. Address of Welcome.
   G. Lloyd Weil, Mayor.
2. Business Session.
3. The Akron Sewage Treatment Works.
   T. C. Schaetzle.

AFTERNOON SESSION

4. Sludge Digestion.
   R. A. Allton.
   Discussion by F. W. Jones and C. D. McGuire.
5. Description and Operation of Elyria Sewage Treatment Plant.
   James R. Collier.
   Discussion led by Geo. B. Gascoigne.
6. Trickling Filter Loadings.
   B. F. Hatch.

EVENING

7. Dinner—6:30 P. M.—Mayflower Hotel.
   Toastmaster—Fred E. Ayer, Dean, College of Engineering, University of Akron.
8. "Balloon Experiences."
   By Ward T. Van Orman.
9. Pictures of U. S. S. "Akron."
   (Courtesy of the Goodyear-Zeppelin Corporation.)

Wednesday, October 14

ROUND TABLE DISCUSSION

TOPICS

1. Grit Chambers; efficient operation.
2. Trickling filters vs. spiders, angleworms and flies.
3. What constitutes odors about a sewage plant.
4. Gas Production.
5. Best method of determining suspended solids.
6. The best method of determining the pH value of a sludge.
7. Diluting water for the bio-chemical oxygen demand test.
8. Experiences with paint about a sewage plant.
9. Lead vs. Leadite for joints in filter distributor mains.

AFTERNOON SESSION

Inspection of Akron and Elyria Sewage Treatment Plants.

F. D. Stewart is secretary and editor, care of State Department of Health, Columbus, O.

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Ohio Conferenc on Water Purification

The Eleventh Annual Ohio Conference on Water Purification is to be held at Lorain, Ohio, with headquarters at the Antlers Hotel on Oct. 15th and 16th.

The program on Oct. 15th includes papers of importance on practical experiences with the ammonia-chlorine and the activated carbon methods for combatting taste and odor troubles.

Other papers of a highly practical value include methods of disposal of sludge from water softening plants and cleaning of chemical solution feed lines.

The second day of the meeting will be devoted to a tour of inspection of the water purification plants at Elyria and Sandusky. The program of the conference follows:

Thursday, October 15

1. Address of Welcome.
   Paul J. Goldthorp, Mayor.
2. Report of Secretary-Treasurer.

PAPERS AND DISCUSSIONS

3. Proof of Effectiveness of the Ammonia-Chlorine Treatment.
   Clarence Bahlman.
4. Studies in the Comparative Value of Three Different Media in Routine Bacteriological Water Analysis.
   Mrs. Rosemary Bole.
5. Report of Committees on Standard Methods.
6. Reforestation of Reservoir Watersheds.
   A. D. Claggette.
7. Twenty-five Years of Water Purification.
   Thos. H. Tristram.

ANNOUNCEMENTS

8. Nominating Committee for New Officers.
9. Inspection of the Lorain Filtration Plant.
   Luncheon will be served at the plant.
1. Election of Officers.
2. Selection of place for next meeting.

PAPERS AND DISCUSSIONS

3. Disposal of Softening Plant Sludge at Marion.
   C. C. Whysall.
4. Experiences in the Use of Activated Carbon.
   C. E. Trowbridge.
   Discussion by Taylor, O'Connor, VanArnum and Schoepfle.
5. Comparison of Turbidity Determination Methods.
   Wm. I. VanArnum.
6. Larval Contamination of a Clear Water Reservoir.
   Clarence Bahlman.
7. Problem of Cleaning Solution Feed Lines.
   C. C. Whysall.
   Discussion by W. B. Lockhart.
8. Demonstration of Model Water Purification Plant.
   F. L. Rollins.
   6:30 P. M.—Dinner at Antlers Hotel.

Friday, October 16

An inspection trip will feature the second day of the conference. The following plants have many points of interest and transportation to them will be available for all the attendance in privately owned automobiles. The route is suggested as follows:

Leave Antlers Hotel 9:00 A. M. for Avon Lake Village—9 miles east on State Route 2.

Leave Avon Lake Village 10:00 A. M. for Elyria Water Purification Plant—1 mile west of Lorain on State Route 2.

Leave Elyria Water Works at noon for Sandusky—32 miles west on State Route 2.

Luncheon—Enroute.

Meet after lunch at Sandusky Water Works.

Adjournment.

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Fall Meeting, New York State Sewage Works Association

The Fall meeting of the N. Y. S. S. W. A. will be held at Ithaca, N. Y., October 16th and 17th, 1931, with headquarters at the Ithaca Savings Bank Building in the Chamber of Commerce Rooms.

The officers: President, John F. Skinner, Rochester, New York; vice-president, Earl B. Phelps, Columbia University, New York City; secretary-treasurer, A. S. Bedell, State Department of Health, Albany, New York.

The program includes a symposium on stream pollution and in the evening the customary "Round Table" is scheduled following the dinner.

The second day will be devoted to a short technical session followed by an inspection trip and the Cornell-Princeton football game offers the afternoon attraction.

Ladies are to be especially well taken care of by the Entertainment Committee as is indicated by the program that follows:

Friday, October 16th

10:00 A. M.-12:30 P. M. Registration. Chamber of Commerce Rooms, Fourth Floor, Ithaca Savings Bank Building.

12:45 P. M. Luncheon, Bank Restaurant, Fifth Floor, Ithaca Savings Bank Building.

AFTERNOON SESSION
Fifth Floor, Ithaca Savings Bank

2:00 P. M. Welcome by Hon. Herman Bergholtz, Mayor of Ithaca. Response by President John F. Skinner.
2:15 P. M. Business Session.
2:45 P. M.-4:25 P. M. Symposium on Stream Pollution.
(a) As It Affects Water Purification.
Professor E. M. Chamot, Cornell University.
(b) As It Affects Biological Life.
Professor J. G. Needham and Professor P. W. Classen, Cornell University.
(c) As It Affects Fish Life.
Dr. Emmeline Moore, New York State Conservation Department.
4:25 P. M. Sedimentation Tank Design and Performance.
Mr. Glenn D. Holmes, Syracuse, N. Y.
Discussion of each paper will follow its presentation.

EVENING SESSION
Fifth Floor, Ithaca Savings Bank

6:45 P. M. Dinner. Bank Restaurant.
8:00 P. M. Round Table Discussion.
(a) Camouflaging Sewage Treatment Plants.
Messrs. C. H. Capen and P. N. Daniels, New Jersey.
(b) Measuring Devices in Sewage Pants.
Professor W. C. Taylor, Union College.
(c) Question Box.
10:00 P. M. Adjournment.

Saturday, October 17th

9:00 A. M. Chamber of Commerce Rooms.
Description of Ithaca Sewage Treatment Plant and of Operation Since Redesign.
Professor H. N. Ogden, Messrs. Glenn D. Holmes and Harry Eustance.
9:45 A. M.-12:00 Noon. Inspection trip to Ithaca Sewage Treatment Plant and to the Cornell University Water Filtration Plant.
12:00 Noon. Buffet Luncheon at Cornell University Drill Hall.
2:00 P. M. Football Game. Cornell vs. Princeton.

ENTERTAINMENT FOR LADIES
Friday, October 16th

10:00-12:00. Assemble at Woman's Community Building after registering at the Chamber of Commerce Rooms.
12:45 P. M. Luncheon at Willard Straight Hall Cornell Campus.
1:45 P. M. Leave Willard Straight Hall for a trip of sightseeing by automobiles around the Cornell Campus. Estey's Glen, West Hill and Taughannock State Park.
4:15 P. M.-5:00 P. M. Organ Recital in Sage Chapel, Cornell University.
6:45 P. M. Dinner in Bank Restaurant.

Saturday, October 17th

9:30 A. M. Woman's Community Building. Brief Talk on the History of the Ithaca Reconstruction Home, followed by a visit to the Home to observe various types of exercises for Infantile Paralysis Convalescents.
12:00 Noon. Luncheon at Cornell University Drill Hall.
2:00 P. M. Football Game—Cornell vs. Princeton.

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37th Annual Convention, American Society of Municipal Engineers

The American Society of Municipal Engineers will convene at the William Penn Hotel, Pittsburgh, Pa., Oct. 19-23, 1931.

That portion of the program of primary importance to engineers and municipal officials will be given on Oct. 21st and follows:

Wednesday, October 21

9:30 WATER WORKS COMMITTEE REPORT AND SYMPOSIUM.
By L. R. Howson, Chairman, Consulting Engineer, Alvord, Burdick and Howson, Chicago, Illinois.
9:30 General Report by the Chairman.....L. R. Howson
9:40 Taste and Odor Removal.....John R. Baylis
9:50 The Use of Zeolite in Softening of Municipal Water Supplies .....D. E. Davis
10:00 Water Supply Lessons from the Recent Drought .....N. T. Veath, Jr.
10:10 Progress in Lime Soda Water Softening Process .....J. L. Porter
10:20 Discussion.
1:30 Refuse Disposal and Street Cleaning Committee Report.
By E. E. Butterfield, Chairman, Consulting Chemist, Forest Hills, New York.
1:50 Discussion.
1:55 "The Other Side of the Public Works Budget."
By Clarence E. Ridley, Executive Secretary, The International City Managers' Association, Chicago, Ill.
2:15 Discussion.
2:20 "Economics of Waste Disposal."
By E. E. Butterfield, Consulting Chemist, Forest Hills, N. Y.
2:40 Discussion.
2:45 Sewerage and Sanitation Committee Report.
By Albert P. Learned, Assistant Engineer, Black and Veatch, Kansas City. Mo.
3:10 "Explosions in Sewers and Sewer Maintenance."
By J. J. Jessup, City Engineer, Los Angeles, Calif.
3:35 "Settling Characteristics of Activated Sludge."
By D. W. Townsend, Principal Assistant Engineer, Milwaukee Sewerage Commission, Milwaukee, Wis.
4:00 "Mechanical Handling of Sewage Solids—a Step Forward."
By E. B. Besselievre, Sanitary Engineering Division, The Dorr Company, Inc., New York, N. Y.
4:25 "New Developments in Sludge Digestion Tanks, Construction."
By J. L. Mason, Sewage Research Engineer, The Hardinge Co., York, Pa.
4:50 "Trade Waste Treatment."
By Michael J. Blew, Research Engineer, Department of Public Works, Philadelphia, Pa.
5:15 "Trade Wastes and Sewage Treatment at Fostoria, Ohio."
By J. F. Laboon, Consulting Engineer, The J. N. Chester Engineers, Pittsburgh, Pa.
5:40 "The Lime-Chlorine Process in Sewage Treatment."
By W. V. Brumbaugh, Assistant Secretary, National Lime Association, Washington, D. C. Discussion by L. H. Enslow, Chlorine Institute, of New York.
Adjournment.

October 19th will be devoted to Committee Reports and general Society business.

The program on Tuesday, Oct. 20th, is devoted to City Planning, Municipal Airports, Traffic and Street Lighting, and Traffic Control.

October 22nd will be devoted to papers and discussions on Bonding, Public Utilities, Paving Practice and Materials.

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Conference, Virginia Water and Sewage Works Association

The third annual conference of the Virginia Water and Sewage Works Association, of which H. W. Snidow, assistant engineer of the Division of Sanitary Engineering of the Virginia State Department of Heath, is secretary-treasurer, will be held Nov. 16 and 17 at the Virginian Hotel, Lynchburg, Va. The tentative program of the meeting follows:

Monday Morning Session, 9:00 to 12:30

9:00 Registration.

PAPERS AND DISCUSSIONS

1. The Lynchburg Water Supply.
By C. L. DeMotte, Consulting Engineer, Formerly City Engineer.
2. Open Service Reservoirs.
By H. A. Johnson, Supt. Filtration, Danville, Va.
Discussions by R. L. Warren, Supt. Water Works, South Boston, Va.
3. Control of Tastes and Odors in Impounded Waters.
By James M. Caird, Chemist, Roanoke Water Works Co., Troy, New York.
4. Announcements.

Monday Afternoon Session, 2:00 to 5:00

1. Measures Used for Removal of Tastes and Odors in Filtered Water.
   At Norfolk—By R. W. Fitzgerald, Chief Chemist, Water Department.
   At Newport News—By E. F. Dugger, Gen. Mgr., Newport News Waterworks Commission.
2. Mixing Chambers and the Importance of Proper Mixing. By M. C. Smith, Engineer, Water & Electricity, Richmond.
3. Metering.
   By E. H. Ruehl, City Manager, Bluefield, Va.
4. Question Box Discussions.
   Members and guests are asked to write on slips of paper any questions which they desire and deposit in the "Question Box." These will be brought up for discussion during the Question Box Sessions.

Convention Dinner, 6:30.
Address of Welcome.
By R. W. B. Hart, City Manager, Lynchburg, Va.

Monday Evening Session, 8:00 to 10:00

Public invited.

1. Recent Important Developments in the Water Works Field. By Linn H. Enslow, New York City, Editor, WATER WORKS AND SEWERAGE.
2. (Address and author not yet decided.)
3. Virginia's Chemical Industry of Today.
   By Prof. Lauren B. Hitchcock, Assoc. Prof. of Chemical Engineering, University of Virginia.

Tuesday Morning Session, 9:00 to 12:30

1. The Hollins Sewage Treatment Plant.
   By W. M. Johnson, of the firm of Wiley & Wilson, Consulting Engineers, Lynchburg, Va.
2. Experiences in Starting a New Sewage Plant.
   By Sterling Williamson, City Engineer, Charlottesville.
   Discussion by Lee H. Williamson, of the firm of Saville & Williamson, Inc., Richmond.
   Discussion by S. L. Grant, Supt. Water and Sewers, Winchester, Va.
3. The Blacksburg Plant.
   By Prof. Francis J. Sette, Department of Engineering, Virginia Polytechnic Inst., Blacksburg, Va.
4. Question Box Discussions.
5. Election of Officers.

Tuesday Afternoon Session, 2:00 to 5:00

1. Pump Tests.
   By H. E. Beckwith, The Pitometer Co., New York City.
2. Visit to Lynchburg Filtration Plant.
   Description by .....
3. Trip through cast-iron pipe manufacturing plant.
   Explanation by .....
4. Adjournment.

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Missouri Water and Sewerage Conference

The annual Missouri Water and Sewerage Conference will be held Oct. 22 and 23 at the Missouri Hotel, Jefferson City, Mo. The program includes the following:

THURSDAY, OCTOBER 22

Address of Welcome.
A New Plan for Financing Public Improvements—William J. Gray.
Discussion by W. B. Rollins.
Developing Public Relations—Judge Milton R. Stahl.
Filtration Plant Problems—L. O. Williams, Jr.
Open discussion.
Sanitary Well Construction—A. J. Fiedler.
Discussion by H. A. Buehler.
Ammoniation, the Topic of the Times—H. S. Hutton, Wallace-Tiernan Company.
Common Sanitary Defects in Missouri Water Supplies and Their Correction—Herbert Bosch.
Discussion by W. Scott Johnson.
A Simple Floc Detector—Its Construction and Use—E. E. Wolfe.

FRIDAY, OCTOBER 23

Odor Control—G. R. Scott.
Discussion by George S. Russell.
Progress in the Treatment and Disposal of Human Wastes—R. E. McDonnell.
Open discussion.
Sewage Disposal and What It Means to Public Health—H. C. Delzell.
Report of committees.
Business meeting and election of officers.
Inspection of Capital City Water Company, Jefferson City.
Luncheon—Courtesy Capital City Water Co.
Round Table discussions—W. Scott Johnson in charge.
Annual dinner, Missouri Hotel dining room.
Entertainment.

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New England Sewage Works Association

The 1931 Fall meeting of the N.E.S.W.A. was held in Providence, R. I., Monday, Oct. 19th, with headquarters at the Maintenance Building of the Providence Sewer Department.

Papers were presented to cover questions of sewer maintenance, sand filtration and a description of the new sewage treatment plant at Providence.

The afternoon was devoted to an inspection trip and the customary dinner, with the "Round Table" following, at the Providence Yacht Club, closed the meeting.

COMING CONVENTIONS

SOUTHWEST WATER WORKS ASSOCIATION.—Annual convention, Jung Hotel, New Orleans, La., Oct. 19-22. Lewis A. Quigley, superintendent, water works, Fort Worth, Tex., is secretary-treasurer.

ROCKY MOUNTAIN SECTION, A. W. W. A.—Fifth annual convention, Oct. 21-23, Denver, Colo. Dana E. Kepner, 226 Continental Oil Bldg., Denver, Colo., is secretary-treasurer.

PENNSYLVANIA WATER WORKS ASSOCIATION.—The 36th annual convention will be held at Atlantic City, N. J., Oct. 21, 22 and 23. F. S. Purviance, Room 327 Telegraph Bldg., Harrisburg, Pa., is secretary.

WISCONSIN SECTION, A. W. W. A.—Convention at Hotel Racine, Racine, Wis., Oct. 26-27. L. A. Smith, Superintendent Water Works, Racine, is secretary.

CALIFORNIA SECTION, A. W. W. A.—Convention at Stockton, Calif., Oct. 28-31. E. W. Green, San Jose Water Works, 374 West Santa Clara St., San Jose, Calif., is secretary.

MISSOURI VALLEY SECTION, A. W. W. A.—Annual convention at Eldridge Hotel, Lawrence, Kan., Oct. 29-31. Earl L. Waterman, professor of sanitary engineering, University of Iowa, Iowa City, Ia., is secretary-treasurer.

MINNESOTA SECTION, A. W. W. A.—Convention at Hotel Lowry, St. Paul, Minn., Oct. 30. R. M. Finch, Wallace & Tiernan Co., Inc., 614 Flour Exchange Bldg., Minneapolis, Minn., is secretary.

NORTH CAROLINA SECTION, A. W. W. A.—Convention at Greensboro, N. C., Nov. 2-4. H. G. Baity, Professor of Sanitary and Municipal Engineering, University of North Carolina, Chapel Hill, N. C., is secretary.

NATIONAL MUNICIPAL LEAGUE.—Annual meeting, Nov. 9-11, at Buffalo, N. Y.

IOWA SEWAGE TREATMENT CONFERENCE.—The 1931 conference will be held Nov. 18, 19, 20 at Iowa State College, Ames, Ia.

NORTH DAKOTA WATER AND SEWAGE WORKS CONFERENCE.—The third annual meeting will be held in Fargo, N. D., Nov. 5, 6 and 7. A. L. Bavone, Bismarck, secretary-treasurer.

Meeting of International Association of Public Works Officials

The annual convention of the International Association of Public Works Officials held at the Hotel Pennsylvania, New York City, included in topics discussed, matters pertaining to sewage disposal for the first time at the New York meeting Sept. 24-25th.

The paper prepared by J. R. McClintock, of New York City on "Sewage Disposal" was presented by Geo. W. Fuller, of Fuller and McClintock, Consulting Engineers and considerable discussion ensued.

Mark B. Owen, Commissioner of Public Work of Dearborn, Mich., opened the discussion with complimentary remarks covering Mr. Fuller's presentation and then gave a rather complete description of results secured on a semi-plant experimental scale treating 250,000 gal. of sewage per day with a novel scheme of sewage treatment to be used by Dearborn. The new plant is now under construction at Dearborn and is described on another page in this issue along with results secured from the experimental plant.

In reply to a question by Mr. Fuller as to how the Dearborn treatment will compare with plain settling Mr. Owen replied that a reduction of at least 67 per cent of the oxygen demand had been had and more was looked for from the large scale operations using 5 p.p.m. chlorine applied to the effluent. He actually expected as much as 75 per cent oxygen demand reduction and the sterilized effluent had been as clear as spring-water.

Mr. Owen stressed the economy of the scheme as compared with biological types of treatment and the plants of large area thus required. Ferric-chloride to serve as the coagulant was to be made on the ground from old tin cans, scrap iron and chlorine gas. Lime was available in the form of spent sludge from the Prestolite Company plant at $1.00 per ton and scrap paper was to be procured through the refuse handling service at the salvage yards.

In reply to another question his thought was that the process would prove particularly attractive where industrial wastes were a problem in the sewers—particularly such wastes as poison the organisms so essential in biological processes.

The chief advantages of the chemically controlled process was its freedom from odors, small area required and low initial costs as well as operating costs. He understood that in some places the degree of treatment which they expected might be less than required, but that in many cases where biological processes are now indicated the municipality might make use of the Dearborn scheme very satisfactorily. This, because such excessive and costly purification as is frequently given sewage, to make it stable and at the same time look attractive, is ofttimes not requisite to prevent nuisance in streams. This, after all, with the effluent made safe from a health standpoint was all that was required and that was what they planned to accomplish with the new plant at Dearborn.

Mr. Fuller, closed the discussion by saying that the Dearborn scheme seems to have many advantages and should have a ready place in the general scheme of sewage treatment.

The remainder of the program was devoted to topics pertaining to snow removal, city planning, organization of departments of public works, municipal air ports, street lighting, sanitation records, and taxation.

Pittsburgh was chosen as the 1932 Convention City and the following were elected officers for the coming year: President, H. D. Bradley, Toronto, Ont.; Vice-President, Carl Schneider, New Orleans, La.; Vice-President, F. L. Costigan, Washington, D. C.; Vice-President, Mark B. Owen, Dearborn, Mich.; Treasurer, P. J. Hurtgen, Kenosha, Wis.; Secretary, J. M. Anderson, Chicago, Ill.

REGISTRATION AT CONVENTION INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS

C. K. Allen, Engineer, Street Cleaning Department, Baltimore, Md.
A. M. Anderson, Chicago, Ill.
L. T. Arpin, Cities Equipment Corp., New York City.
J. W. Aspinwall, The Elgin Corporation, Marathon, N. Y.
W. J. Banks, Asst. Division Engineer, Division of Water, Newark, N. J.
John Beirne, The White Co., New York City.
James Berg, Sanitary Commissioner, White Plains, N. Y.
Davis Bloomberg, Alderman, Minneapolis, Minn.
L. P. Booz, City Engineer, Perth Amboy, N. J.
Harold D. Bradley, Deputy Street Commissioner, Toronto, Canada.
Robert B. Brooks, Director of Streets & Sewers, St. Louis, Mo.
A. M. Buchanan, Pittsburgh Des Moines Steel Co., Detroit, Mich.
T. B. Buckley, Minneapolis, Minn.
Dr. E. E. Butterfield, Forest Hills, N. Y.
Edgar J. Buttenheim, Pres. & Mgr., American City Magazine, New York City.
Paul R. Byrnes, Mgr., Chamber of Commerce, Pittsburgh, Pa.
W. H. Carrigg, Sioux City, Iowa.
Geo. H. Cavanaugh, Supt. of Accts. & Finance, City Hall, Allentown, Pa.
F. P. Close, Director of Public Works, East Hartford, Conn.
W. G. Conrath, District Supt. of Bureau of Streets, Chicago, Ill.
T. L. Costigan, Supt. of Street Cleaning, Washington, D. C.
J. J. Curran, Supt. of Streets, New Brunswick, N. J.
H. M. Daniels, Mgr., Four Wheel Drive Co., New York City.
A. F. Damon, Chief of Bureau of Public Works, Upper Darby, Pa.
F. L. Damon, Solvay Sales Corp., Syracuse, N. Y.
Russell E. Dean, Morse-Boulger Co., New York City.
D. Ralph Dedrick, Deputy Commissioner of Public Works, Yonkers, N. Y.

Reception of the Members and Guests Attending Convention of the I. A. P. W. O. by Mayor James G. Walker at City Hall, New York, Sept. 25

L. E. Dempsey, Chief of Sanitation, Greensboro, N. C.
George C. Dodge, The Elgin Corpn., New York City.
Henry D. Dolge, Asst. Supt. of Streets, Milwaukee, Wis.
Thomas J. Donavan, Asst. Supt., Bureau of Street Cleaning, Newark, N. J.
John E. Doran, Vice-Pres., B. Nicoll & Co., 292 Madison Ave., New York City.
Ralph D. Earle, Jr., Pittsburgh Des Moines Steel Co., 50 Church St., New York City.
George Eartol, Expanding Sewer Machine Co., Nappanee, Ind.
William E. Eastman, District Passenger Agt., Pennsylvania R. R., New York City.
R. C. Engels, District Representative, 130 Centre Ave., New Rochelle, N. Y.
L. H. Enslow, Research Engineer, Chlorine Institute, New York City.
D. C. Fenner, Mack Truck Co., New York City.
Chas. H. Fetterly, Mayor, Bound Brook, N. J.
H. W. Fledderman, Chief, Division of Street Cleaning, Louisville, Ky.
John S. Flockhart, Asst. Eng., Newark Street Cleaning, Newark, N. J.
A. Prescott Folwell, Public Works, New York City.
Frank H. Ford, Huntsville Fiber & Veneer Works, Huntsville, Ala.
George W. Fuller, Consulting Engineer, 170 Broadway, New York City.
W. J. Galligan, Asst. Supt. of Streets, Chicago, Ill.
James Garberg, Supt. of Streets, Minneapolis, Minn.
M. C. Gearen, Supt. of Incinerators, Racine, Wis.
R. Gerrabrant, *Engineering News Record*, New York City.
Fred Gettleman, Pres., F. Gettleman Co., 4400 State St., Milwaukee, Wis.
J. E. Gill, Engineer, Philadelphia, Pa.
Fire Chief Gilson, F. H. Lovell Mfg. Co., Arlington, N. J.
E. C. Goodwin, Advisor to Chairman of Sanitary Commission, New York City.
Irving M. Goss, Deputy Commissioner of Streets, South Bend, Ind.
I. E. Gottlieb, Supt. of Sanitation, St. Paul, Minn.
Chas. E. Grubb, American Road Builders Association, Washington, D. C.
N. K. Haig, Chevrolet Motor Co., Detroit, Mich.
Chas. G. Hanna, Walter Motor Truck Co., Syracuse, N. Y.
W. M. Hannan, Jr., New York City, The Garbage Man.
George W. Hart, Supt. of Public Works, Glens Falls, N. Y.
John S. Herron, President of Council, Pittsburgh, Pa.
W. E. Hess, Solvay Sales Co., Syracuse, N. Y.
Fred M. Herzig, Asst. Supt., Bureau of Street Cleaning, Newark, N. J.
Lester W. Herzog, President of the Common Council, Albany, N. Y.
A. P. Heyer, Director of Public Works, Montclair, N. J.
S. A. Hill, Municipal Sanitation, New York City.
P. J. Hurtgen, Director of Public Works, Kenosha, Wis.
Chas. T. Hvass, Chas. Hvass & Co., Inc., New York City.
J. E. Jackson, Pittsburgh Des Moines Steel Co., Pittsburgh, Pa.
H. S. Jenkins, The White Co., Long Island City, N. Y.
Adam Jennetty, Street Commissioner, 459 Johnston St., Perth Amboy, N. J.
C. D. Joyce, Superintendent of Scavenging, Ottawa, Canada.
Gerard W. Kellog, Dept. of Sanitation, New York City.
John J. Kinney, Supt. of Sewers, New Brunswick, N. J.
Geo. W. Kuhlman, The Heil Co., Long Island City, N. Y.
Herman Kurs, Cities Equipment Co., Long Island City, N. Y.
J. C. Landon, Department of Sanitation, New York City.
P. J. Leahy, Commissioner of Public Works, Troy, N. Y.
Chas. E. Louden, Pittsburgh Des Moines Steel Co., 50 Church St., New York City.
E. H. Lund, Street Supervisor, Minneapolis, Minn.
Joseph F. Maloney, Deputy Comm. Public Works, Perth Amboy, N. J.
Karl M. Mann, President, Municipal Sanitation, New York City.
W. S. McGrane, Merchants Association, New York City.
C. A. McKernan, Treas., International Assn. of Public Wks. Officials, Utica, N. Y.
Philip A. Merian, City Engineer, New Britain, Conn.
Edwin A. Miller, Supervisor of Maintenance, Rochester, N. Y.
Gustave A. Moe, Committee on Uniform St. Sanitation Records, Chicago, Ill.
F. M. Montgomery, Sioux City, Iowa.
R. L. Morton, Cities Equipment Corpn., Philadelphia, Pa.
S. Muenz, Asst. Eng., Department of Sanitation, New York City.
Miss Ann Murphy, Assistant Superintendent of Streets, Chicago, Ill.
H. J. Neely, Supt. of Highways, Pittsburgh, Pa.
A. A. Nelson, Sales Manager, Nelson Iron Works, Passaic, N. J.
N. P. Nelson, President, Nelson Iron Works, Passaic, N. J.
D. F. O'Brien, Alderman, Minneapolis, Minn.
E. T. O'Conner, Mechanical Draftsman, New York City.
W. O'Donnell, Chevrolet Motors, New York City.
I. S. Osborn, Vice Pres., C. O. Bartlett & Snow Co., Cleveland, Ohio.
Mark B. Owen, Commissioner of Public Works, Dearborn, Mich
E. H. Paffrath, Sewer Commissioner, St. Louis, Mo.
Wm. Parrish, Int. Harvester Co., Chicago, Ill.
G. Paskos, President, Cities Equipment Corp., New York City.
A. J. Paul, City Commissioner, Ann Arbor, Mich.
D. O. Paulson, President, Municipal Supply Co., South Bend, Ind.
T. C. Pearson, Asst. Engr., Dept. of Sanitation, New York City.
B. J. Penn, H. O. Penn Machinery Co., New York City.
J. J. Petranek, Commissioner of Public Works, Cicero, Ill.
James Phillips, Jr., Supt. of Incineration, Yonkers, N. Y.
J. D. Pitcher, Indianapolis, Ind. (Philip Carey Co.—District Mgr.)
J. A. Powers, Asst. Sales Mgr., Four Wheel Drive Co., New York City.
G. A. Pratt, District Representative, Boston, Mass.
B. E. Priddy, Chas. Hvass & Co., Inc., New York City.
W. C. Robertson, Manufacturer Representative, New York City.
A. E. Roche, Commissioner of Public Works, Troy, N. Y.
Milton Rosen, Commissioner of Public Works, St. Paul, Minn.
G. C. Saffran, Sales Engineer, Edgerton, Wis.
A. J. Scaife, The White Company, Cleveland, Ohio.
Carl Schneider, M. E., New Orleans, La.
Dr. W. H. Schroeder, Jr., Sanitation Commissioner of New York City.
J. H. Sharkey, Sales Mgr., Walter Motor Truck Co., New York City.
C. K. Simon, Calco Chemical Co. (Research Dept.), Plainfield, N. J.
Samuel Simon, Secy. & Treas., FitzGibbon & Crisp, Trenton, N. J.
L. C. L. Smith, Engineer of Sanitary Commission, New York City.
J. H. Sneider, The Elgin Corp., Pittsburgh, Pa.
A. Sprung, Municipal Street Sign Company, New York City.
H. A. Steiert, Philadelphia, Pa.
L. G. Stelzle, Walter Motor Co., New York City.
C. E. Stevens, Assistant Manager, Int'l Harvester Co., New York City.
Alden E. Stilson, Morse Boulger Co., New York City.
Ralph I. Stitt, Highway Service, Inc., New Bedford, Mass.
Donald C. Stone, Staff Director, Committee of St. Sanitation Assn., Chicago, Ill.
Irving Stone, Supt. of Incinerating, Providence, R. I.
H. W. Thomas, New York City.
James F. Thompson, Elgin Sweeper Co., Peekskill, N. Y.
Raymond E. Thompson, Street Dept., South Bend, Ind.
S. A. Thompson, Street Dept., South Bend, Ind.
Geo. H. Thomson, Morse Boulger Co., New York City.
Wm. M. Tyler, Elgin Corp., New York City.
Chas. Upham, Director, American Road Builders Assn., Washington, D. C.
A. R. Von Keller, Cities Equipment Corp., New York City.
Geo. M. Waer, Asst. Supt. of Sewers, Newark, N. J.
Maurice Walter, Walter Motor Co., New York City.
Frank E. Waterman, Commissioner of Public Works, Providence, R. I.
E. W. Watts, President, U. S. Machinery Co., New York City.
William E. Winship, Street Commissioner, Indianapolis, Ind.
E. A. Wood, Winnipeg, Canada.
W. W. Young, Consulting Engineer, 90 West St., New York City.

EDITORIALS

An Acknowledgment

AS the embryo editor of these pages, it gives me great pleasure to acknowledge here the letters and messages of congratulations received incident to the commencement of the new work.

For many years I have been a reader of the Gillette Publications and for the past two years have acted in the capacity of Associate Editor of WATER WORKS AND SEWERAGE. During this period of service I became convinced that this magazine has given its readers a great deal for the modest subscription charge. The contributions of Baylis, Downs and Kimberley as associate editors have been alone worth the subscription price, as evidenced by the high compliments received by the publishers.

When offered the position as editor I wondered what I might do to help improve WATER WORKS AND SEWERAGE. Realizing the possibilities, I accepted the offer.

Several definite plans have been developed toward bettering this publication. Some of these are largely the result of suggestions made by subscribers and advertisers, and here I wish to say that the voicing of opinion and suggestions from the readers of these pages and by our advertisers will not only be appreciated by the editors but will materially assist us in constantly giving you and others a more valuable publication than could otherwise be possible.

It is my hope that with such assistance I can do as one of my well-wishers phrased his message, viz: "make an already *good* magazine *better*."

Again with appreciation of the thoughtfulness of my well-wishers and repeating the request for suggestions, and for criticisms when deserved, and realizing that *"No one man can see everything,"* I am,

Faithfully yours,

L. H. ENSLOW,
Editor.

Chemical Precipitation Anew

WITH the development of a novel and interesting process of sewage treatment at Dearborn, Mich., a modified and improved chemical precipitation scheme appears on the scene.

The use of moderate dosages of chemicals and the "sweeping" suspension of paper pulp added, together with the upward flow and straining effects secured by the novel design and operation of a "drifting magnetite" filter bed, lends interest to the method.

The use of paper pulp would seem to serve in several directions, not the least being to assist in sludge dewatering operations and the production of a more combustible filter-cake low in moisture content. There seems to be some speculation as to the merits of the added pulp insofar as improvement in quality of effluent is concerned, but such observation as the following one points to its having some purification merit also.

On a polluted river there is located a paper and board mill. Most of the river flow is at times utilized by this mill and is returned to the stream in the form of "white-water" waste. The water in passing through that mill is returned to the stream in better condition than before passage through the process. While it is true that chlorination of the water is practiced in this mill to prevent "slime" troubles nevertheless it seems proper to credit the tremendous surface and the adsorptive capacity of the suspension of pulp which is thereafter removed in the form of manufactured products with a goodly share of the purification observed in the stream during the drought period of 1930.

If the Dearborn authorities can duplicate the experimental plant results in the large scale operations and overcome practical operating difficulties and produce results at cost figures anticipated for chemicals, labor, etc., there will be a ready field for this super chemical precipitation process of sewage treatment.

The process seems to have many potential merits which will be put to a final test in the large plant, pictured on the front cover and described elsewhere in this issue, now under construction at Dearborn.

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The Increasing Hazards of Sewage Disposal

THE fatal explosion at the Woonsocket, R. I., sewage works within the month, which is described elsewhere in this issue, serves to further emphasize the fact that in recent times the business of sewage treatment and disposal has become continuously more hazardous.

Explosions in large sewers are becoming frequent occurrences. Damages done to expensive paving, and to buildings at times, warrants more strict control over sewer systems. The remarkable part of such explosions, hurtling heavy manhole lids through space as they frequently do, has been the small number of fatalities to citizens on the streets.

Sewer ventilation without odor nuisance resulting is as yet a problem unsatisfactorily solved and constitutes one of the major difficulties now under study in hopes of evolving a practical means of solution by the Metropolitan District of London, Los Angeles, Calif., and other large cities.

Hydrogen sulphide gas produced in sewers and at sewage treatment plants constitutes another hazard and has within the past 18 months resulted in the death of at least three men in America.

Without doubt carbon-monoxide has been held to blame in numerous cases for the illness or death of sewer workers where hydrogen sulphide was most probably the responsible agent. It is not generally appreciated that this treacherous gas is practically as deadly as hydrocyanic-acid gas. When in high concentrations it is without odor and this characteristic has resulted in death whereas its presence in lesser concentrations would have been detected by its odor, which would have served

All communications for the Editorial Department of WATER WORKS AND SEWERAGE should be addressed to L. H. Enslow, Editor, at the eastern offices of the Gillette Publishing Co., 420 Lexington Ave., New York, N. Y.

as a warning of danger or at best would have resulted only in non-fatal poisoning should the warning have been ignored. Hydrogen sulphide mixed with air is in itself combustible but there is no record that explosions have been caused by its presence in sewers.

In septic tanks, separate sludge digestion tanks and Imhoff tanks methane (marsh gas) constitutes the important combustible portion of the gas generated. Sludge gas has a heating and power generating value about equal to that of natural gas.

Sludge gas taken alone is non-explosive, whereas its mixture with air (oxygen) in varying proportions produces mixtures of varying degrees of explosiveness. It is such mixing that effectively produces power generation when air and sludge gas is drawn simultaneously into the intake of gas engines at sewage plants. It was such a mixture of gas and air that was ignited in the Woonsocket tank. Starting with a hissing flame being emitted from a manhole the ignition terminated with that powerful and fatal blast.

The remarkable part of the entire question of sludge gas utilization at sewage works has been the absence of fatal explosions at other and older plants. There have been minor accidents to sludge tanks and cases are known where the pressure generated by gas production in closed off sludge lines and pumps has resulted in rupture of this equipment. It seems remarkable that such small living creatures as bacteria can work against such odds as the confining strength of cast iron pipes.

At the 1931 meeting of the New Jersey Sewage Works Association at least one member issued a note of warning concerning the operation of sludge digestion tanks and gas holders. The problem seems to be one of elimination of carelessness on the part of the workmen together with a better appreciation of the hazards of allowing air to enter the sludge digestion tanks or gas holders.

It is now considered best practice to provide gas holders, floating covers or means to insure a full tank of sludge or liquid at all times in order to avoid sucking in of air to the digestion unit when drawing out sludge.

The Woonsocket experience will serve to emphasize the need for extraordinary precautions when working with situations where sludge gas is involved and proves once more that carelessness may mean certain death or destruction.

There are other known occurrences of digestion tank rupture apparently due to explosion. These, however, were non-fatal and no witness was present to explain the probable cause. Whatever the study and speculation as to the real cause of the Woonsocket explosion may bring forth, it is essential that those responsible for sewage plant operation realize that they are dealing with a chemical-engineering problem in which hazard exists and that "safety-first" measures must be enforced.

L. H. Enslow

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Nine Planetoids That Cause Weather Cycles

In a paper read June 18 before the American Meteorological Society the editor showed that the little planet Ceres causes a rainfall cycle equal to its orbital period of 4.60 years, and a much more pronounced or main cycle of 11/12 thereof, or 4.22 years. The peaks of these two cycles coincide every 50.64 years causing a supercycle. In this respect Ceres resembles each of the 9 large planets.

Astonishing as it is that so small a planet as Ceres, can cause noteworthy rainfall cycles, it is perhaps more astonishing that several planetoids much smaller than Ceres are even greater generators of rainfall. The editor has found that each of the following 8 planetoids also causes rain cycles of importance: Juno, Harmonia, Hygeia, Vesta, Leucothea, Pales, Flora, and Amphitrite. Stewart's method of cyclogram analysis has already been applied successfully to 8 planetoids, and is likely to yield similar results as to several others. When this part of the editor's weather research is finished, all the cycles will be published in "WATER WORKS AND SEWERAGE," along with cyclogram analyses that establish the existence of each cycle beyond doubt.

In addition to the three above mentioned cycles that each planet causes, each is also responsible for a fourth cycle which is usually 1/8 or 1/12 the length of the main cycle. The main cycle appears to be due to the magnetic effect of a shell of electrons around the planet, corresponding to the Heaviside layer of electrons in our upper atmosphere. The poles of these electron shells evidently rotate slowly clockwise, which accounts for the fact that the main cycle is shorter than the orbital period; for this rotation causes a pole of the magnetic axis to point most nearly earthward at intervals slightly less than the orbital period. In the case of the 9 planetoids, the main cycle is 11/12 of the orbital period.

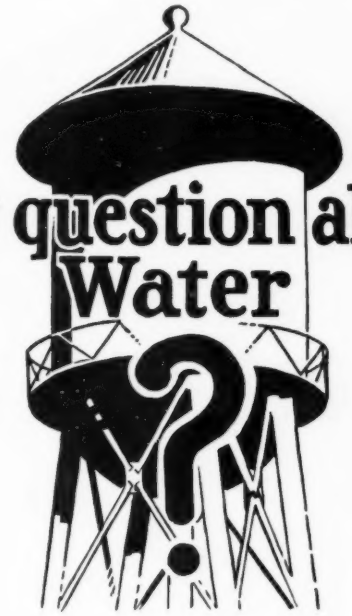
Apparently the upper field magnetic axis nutates or nods periodically, usually making 8 or 12 nutations in a main cycle, thus causing subcycles. The rotative axis of the earth nutates periodically, and analogy leads to the inference that the magnetic axis of the electron shell encasing a planet also nods. At any rate, acting upon this hypothesis, the editor has found a subcycle for each of the 9 large and the 9 small planets. All these cycles and subcycles are found in rainfall, annual tree-rings, annual clay-varves of ancient glacial lakes, earthquake frequency, and annual flood levels of the Nile as well as in sunspots and in the frequency of auroras. All these phenomena are evidently affected, and probably caused by the magnetic forces of the planets and the sun itself.

The fact that a planet is small and far distant from the earth is no bar to its having a marked effect upon our atmosphere. The atmosphere contains several electron shells, which are thrown into tidal waves by the magnetic forces of the planets, the sun and the sunspots. The most familiar of these tidal waves is the 12-hour cycle of barometric pressure, which is caused by the sun.

Each planet should be regarded as a nucleus or core around which exist one or more rotating shells of electrons, and to these shells we must look for the forces that throw the terrestrial electron shells into periodic tidal distortions.

When our electron shells are thus periodically lifted away from the earth, electrons tend to flow out of the earth into the air, ascending in spirals that cause the whirling storms that characterize our climate. The mere release of electrons tends to cause rain, for they act as nuclei upon which atmospheric moisture condenses. But their ascending motion also aids condensation by lifting the moisture into cooler regions aloft.

H. P. Gillette



Any question about Water

Two "Pittsburgh-Des Moines" tanks of 250,000 gallons capacity — 500,000 gallons total—have just been completed this summer for the City of Olympia, Washington. The photograph shows the south tank — diameter 32 feet, 106 feet to upper water level and 74 feet 6 inches to the balcony.

The other tank, erected on the east side of the city, also has a diameter of 32 feet and stands on a slightly lower steel tower, 85 feet to the water level and 53 feet 10 inches to the balcony.

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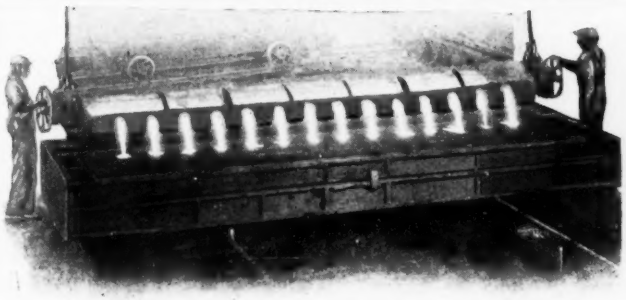

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WITH THE MANUFACTURERS

Griffiths Joins Timken Organization

Mr. F. J. Griffiths has joined the Timken organization at Canton, O. He has been elected director and president of The Timken Steel & Tube Co. M. T. Lothrop, president of The Timken Roller Bearing Co., has been made chairman of the Board of The Timken Steel & Tube Co. Mr. Griffiths comes to the Timken Company with vast experience and a broad understanding of the present problems of the steel industry, with which he has been prominently identified for 30 years. Until recently he was associated with the

F. J. Griffiths

Republic Steel Corporation in the capacity of president of the Republic Research Corporation. Mr. Griffiths began his career in the Steel Industry with The United Steel Co. at Canton, and later helped to organize The Central Steel Co. in Massillon, O., of which he was president and general manager. When these two companies were merged to form The Central Alloy Steel Co., he was chosen chairman of the board, which office he held until the Central Alloy merger with Republic.

LaMonte J. Belnap Made Chairman of Worthington Executive Committee

The Board of Directors of Worthington Pump and Machinery Corporation has announced the election of LaMonte J. Belnap as chairman of the executive committee of that corporation. Mr. Belnap is succeeded as president by Harry C. Beaver, formerly vice president. As chairman of the executive committee, Mr. Belnap maintains his active part in directing the manufacturing, sales and financial activities of Worthington. Mr. Belnap also is president of the Consolidated Paper Corporation, Ltd.

LaMonte J. Belnap has an international reputation as an industrialist and financial organizer. His success in bringing the Worthington Corporation to the first rank of American manufacturers is but one of many such feats of his sound management principles. In the selection of the new president, Mr. Beaver, Worthington is equally fortunate. Mr. Beaver has been associated with Mr. Belnap in various enterprises for the past 25 years.

General Water Treatment Corporation Acquires American Zeolite Corp.

The business of the American Zeolite Corp., manufacturers of Decalso, a synthetic base exchange material used in the softening of water, was acquired Oct. 1, 1931, through stock ownership by the General Water Treatment Corp. The business will be operated by the American Zeolite Corp. as a unit of the General Water Treatment Corp. with offices at 440 Fourth Ave., New York.

The General Water Treatment Corp. was organized in 1930 and at that time acquired The Permutit Co. and the Ward-Love Pump Corp. Through purchase by The Permutit Co., it took over the zeolite and lime soda water softening and filter business of the Paige & Jones Chemical Co.

According to W. Spencer Robertson, president of the General Water Treatment Corp., the American Zeolite Corp. will hereafter manufacture its synthetic zeolite Decalso at Birmingham, N. J., under license granted by The Purmutit Co. under the basic patents for synthetic zeolites: Massatsch U. S. No. 1,343,927 and Rudorf U. S. Nos. 1,304,206 and 1,263,707.

R. V. Donnelly Terminates Connection with The Paradon Co.

R. V. Donnelly announces that he has terminated his connection with Paradon Co. of Arlington, N. J., manufacturers of chlorinators. About a year ago, Mr. Donnelly disposed of his interests in the Paradon Manufacturing Co., which he had managed for several years, to a new organization known as The Paradon Co. and, for the past year, he has maintained his connection with the latter organization on a part time basis. Mr. Donnelly, after a short vacation, hopes to engage in some enterprise in the sanitary, engineering or allied fields.

New Sales Manager for Barber-Greene Co.

The Barber-Greene Co. of Aurora, Ill., manufacturers of material handling equipment, announce the appointment as general sales manager of F. D. Hooper, formerly sales manager of the Lidgerwood Manufacturing Co. of Elizabeth, N. J. It is felt that he is thoroughly qualified for the position, both as an engineer and sales executive, and that his coming will definitely strengthen the organization. His selection was made only after much study and many interviews with important men in the industry.

F. D. Hooper

Mr. Hooper was born and raised on the "sidewalks of New Work." He received his Mechanical Engineering and Electrical Engineering degrees at Sibley College, Cornell University, graduating in the class of 1907. He was employed by the Lackawanna Steel Co. (now Bethlehem Steel) and the Boston & Maine R. R. before starting his 24 years of continuous service with the Lidgerwood Manufacturing Co.

Announcement

The Birmingham Office of the Independent Pneumatic Tool Company has moved from the Comer Building to 915 North Seventh Avenue. The new location has warehouse facilities which will enable the Birmingham office to carry a complete line of pneumatic and electric tools, as well as spare parts. H. F. Halbert is manager.

WATER WORKS AND SEWERAGE

NOV. 1931

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CHLORINATION OF LOS ANGELES WATER SUPPLY

By CARL WILSON

Director of Sanitation,
Department of Water and Power,
Los Angeles, Calif.

CHLORINATION of the Los Angeles water supply was initiated in 1914 treating raw surface water diverted from the Los Angeles River. Department officials were frankly skeptical and they looked upon the process as a temporary expedient to be practiced only until the program of constructing infiltration galleries in the gravels underlying the river should be completed, thus terminating the use of surface water. At this time the new Owens River supply reached the city but since it had been held in storage for a minimum of three months under conditions which precluded the chance of repollution, it was not considered necessary to subject it to the new treatment and fear was entertained that much trouble might be encountered from chlorine tastes. Consequently no new installations were made for several years.

In the meantime the newly promulgated Treasury Department standard for the bacterial content of water to be used on interstate carriers was arousing the interest of water purveyors in California, and the Los Angeles Water Department officials began to look upon chlorine with more favor as a possible means of bringing the Owens River water up to this standard during the rainy season and it was realized that something should be done to protect consumers against the possibility of water-borne disease. At that time aqueduct water reached the city proper only through Lower Franklin Reservoir and it was decided to treat at this point. Flow out of the reservoir is constantly fluctuating in volume, corresponding to the vagaries of consumption, but the inflow from the upper reservoir through the Lower Franklin Canyon power house was always at the uniform rate of 100 second feet. At the time this installation was proposed we did not have great confidence in the satisfactory performance of automatic chlorinators, so it was decided to use manual control machines of the then new vacuum type and place them at the power house to treat the water as it entered the lower reservoir, whose capacity at that time (before enlargement) was 375 m.g. Two machines were accordingly housed in a concrete structure built over the power house tail race, and they were continued in service for several years. Because of the long retention in the reservoir, it was feasible to heavily over-dose without fear of taste in consumption.

The next installation was made with the completion of Stone Canyon Dam, and here the use of automatic machines was imperative. To produce injector water under the necessary pressure, and to be independent of interruptions to the electric power, ram-type of pumps were used to boost the water pressure operating injectors on the compensator pressure type chlorinators. All equipment was installed in duplicate and the plant when completed was regarded as strictly modern. Recently high pressure water from a main on Mulholland Drive made it possible to eliminate the injector pumps, but they are still retained as standby equipment.

A similar plant was next built under Mulholland Dam at Lake Hollywood, to be followed shortly by what is still our largest chlorination plant, at Lower San Fernando Reservoir. This plant was designed to treat fluctuating flows in two different trunk lines leaving the reservoir, and against the protests of the chlorinator

manufacturers, Pitot tubes were installed to actuate vacuum type automatic chlorinators. In an effort to insure uninterrupted chlorination new and novel devices were introduced at this station, which have subsequently been found to be needed and have operated satisfactorily for several years. An injector water supply was required under a pressure of 150 lb. per sq. in. and to provide this three direct connected motor driven Quimby screw

Fig. 1.—Chlorinating Station at Griffith Park, Los Angeles—Typical of the Housing of the More Recent Installations

pumps, any one of which could carry the entire load, were provided. In case of interruption to the electric current feeding these pumps a 4-cylinder Novo gasoline engine was installed, connected through a clutch to a Worthington triplex pump. A sequence switch, designed and perfected by our own engineers, which was storage battery operated and which received its operating impulses from pressure fluctuations in the injector lines, was installed to automatically control the plant. Whenever the injector pressure falls below a certain point the sequence switch will cut in the next Quimby pump, or, in case of temporary failure in electric energy, it will start the gasoline engine, which is automatically choked, and which, when it reaches full speed, throws its own clutch, cutting in the Triplex pump. The latter furnishes injector water under the required pressure until the operator has repaired the primary pump, or until the electric current returns and remains constant at full voltage for 60 seconds. At the end of this interval the sequence switch throws into operation again one or more of the motor driven pumps which had been running previous to the interruption and shuts off the gasoline engine, which as it stops throws out its own clutch and choke. Recent developments in the San Fernando Valley have made available water from a high service main under sufficient static head to make injector pumps unnecessary, but the installation is still retained as standby equipment for emergency purposes. It functions entirely automatically throughout the cycles, and has been dependable.

From Cylinders to Ton-Containers.—One ton containers were employed for the first time on the Los Angeles system at the San Fernando Station. A crane was provided to handle them and a special form of lifting clamp was devised to facilitate operation. Its construction and use will be apparent from the illustration, showing it suspended near the chlorine container. It is somewhat of a glorified coat-hanger of the collapsible type.

The most recent automatic plant to be added was made possible below Lower Franklin Reservoir by the installation of a Venturi tube and Simplex recorder. Vacuum machines were used, fed by injector water from the upper reservoir, so that booster pumps were not required. As a consequence the building could be compact and because it had to be located in a high class residential district, the architectural appearance was of importance. Double doors were ruled out, so special means had to be found to handle the one ton chlorine cylinders through a window by novel equipment.

Our latest station was built in Griffith Park, where two conduits could be protected with one structure, and again the architectural features of the building demanded special attention, but double doors to accommodate the ton containers were possible by the protecting aid of a hedge. Injector water is available here under line pressure, so that booster pumps are not required. A power driven blower has been provided to ventilate the chlorinator compartments in case of chlorine leaks, and every provision which has been suggested by 15 years experience in chlorination has been incorporated to insure continuous operation, as well as to protect the operators and equipment against leaks. Electric heat is provided to facilitate chlorine feed in cold weather.

Gas masks are provided at all stations, and two full time mechanics are assigned to maintain chlorine machines and auxiliary equipment in perfect working order. Chlorine feed lines, solution lines and injectors are in duplicate at all plants.

At present Los Angeles has twelve chlorination stations, protecting various units in its complex water supply system, while two additional plants are being added this summer in outlying points in the San Fernando Valley.

Chlorination Control.—Each morning, between 8 and 12 o'clock, the operator at each plant telephones chlorination data for the previous 24 hours to the department laboratory, where the figures are recorded on a special summary sheet showing the amount of water passing the plant in the intervals between readings, weight of chlorine fed, the actual application in pounds per million gallons, and the ortho-tolidin reading of residual chlorine present twenty minutes after chlorine application. The bacteriological laboratory findings on

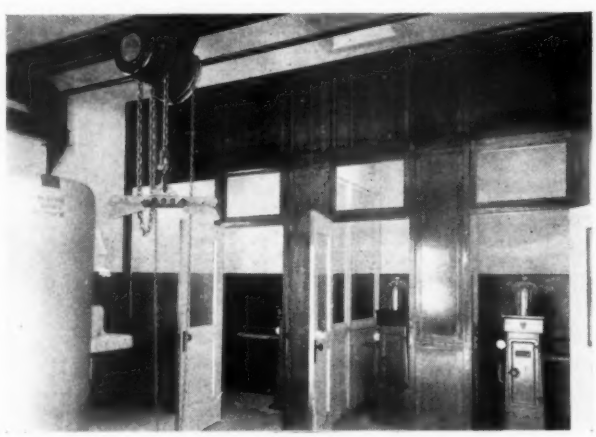

Fig. 2.—Interior Griffith Park Chlorinating Station; Chlorinators in Individual Ventilated Booths; Ton Containers Lifting and Handling Clamp Is Hanging on Chain of the Hoist

control samples are also recorded on this summary sheet, and changes in dosage are made by the laboratory in accordance with the data on this sheet. Residual chlorine concentrations are not allowed to drop below 0.1 p.p.m. and are not supposed to exceed 0.2 except during heavy storms when pollution of open reservoirs by surface run-off is feared, when it is allowed to go as

high as 0.4 p.p.m. No taste troubles are experienced at 0.2 p.p.m. residual, but complaints generally accompany 0.3 and are vociferous when the readings reach 0.4 p.p.m. under normal water conditions. Readings as high as 0.5 have been recorded during storms without complaint, showing the advisability of raising the dosage at such times. The protection afforded by chlorination is indicated by the fact that no case of water borne disease has been known in Los Angeles during the period which the system has been municipally owned, and our sole reliance has been upon chlorination backed by storage, and careful protection of impounding and distribution reservoirs. The total cost of double chlorination (all Owens River water used in the city proper is treated twice) over the last ten years, including all fixed and operating charges is 10 ct. per capita per year, based on a per capita consumption of 116 gal. per day.

Chlorine for Algae Control.—Chlorine may also be used as an algicide, and experience seems to corroborate the *a priori* assumption, based on phylogenetic relationships, that the more closely related to the bacteria an alga may be, the more effective chlorine becomes in its destruction. Conversely, the farther it may be removed from the bacteria, the greater the value of copper sulphate as a control agent. Protococcus types are the most primitive of the algae, and it is not greatly differentiated from the bacteria. Moreover, all water works men who have had to combat its growth realize that copper salts produce little effect upon it. When the Los Angeles Water Department realized it must either find a way to check a rampant growth of Protococcus or temporarily abandon the use of one of its largest and most important distribution reservoirs, it was decided to experiment with chlorine. The Wallace and Tiernan Company loaned the city a 750 lb. vacuum machine for the work, and this was mounted upon a hastily built wooden barge along with a gasoline driven pump to supply injector water. Fifteen cylinders of chlorine fed the machine and an effort was made to apply a dose of 15 lb. of chlorine per acre of water surface. The experiment proved that 0.5 p.p.m. of chlorine was sufficient to destroy the Protococcus without producing complaints of objectionable odors or tastes, while the reservoir was continuously maintained in service.

Fig. 3.—Field Laboratory, Experimental Sewage Treatment and Recovery Station, Los Angeles

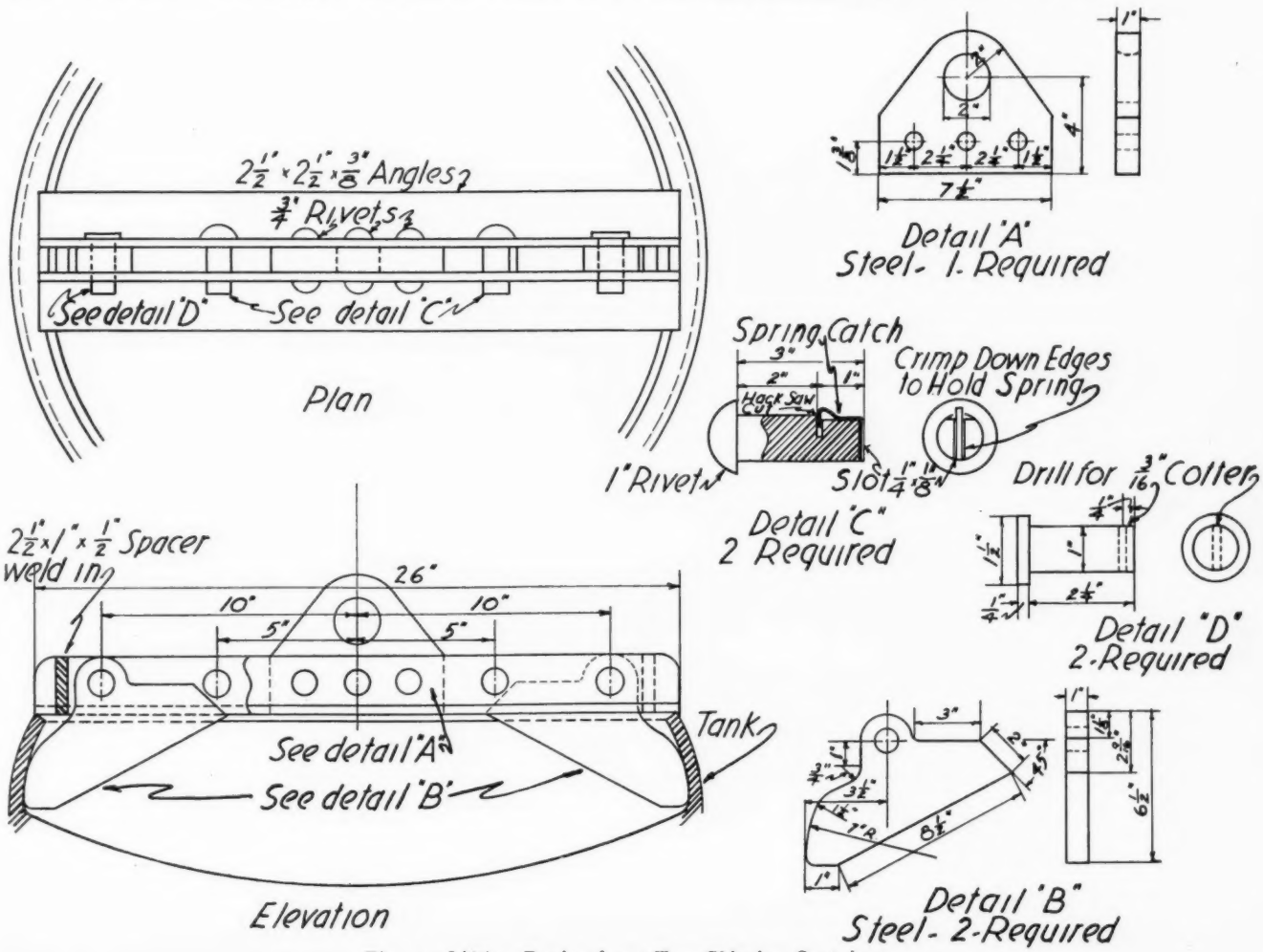

Fig. 4.—Lifting Device for 1-Ton Chlorine Containers

As a consequence of this demonstration, the department purchased four 750 lb. machines of the short pedestal vacuum type, designed for use on boats, and is mounting them upon individual barges with all associated equipment, as a permanent part of its algicidal arsenal.

Portable Chlorinating Unit.—The latest addition to the Sanitation Division's equipment is a portable emergency chlorination plant mounted upon a truck trailer. It carries a 300 lb. vacuum pedestal type Wallace and Tiernan chlorinator, together with a pump to supply injector water, a platform balance upon which is mounted a special carrier for the chlorine cylinders, and means for bathing the cylinders in flowing water to prevent "freezing" during heavy chlorine withdrawal. The injector pump is driven by either gasoline or electric motor, as may be more convenient, and a rebuilt Ford speedometer shows how many gallons of injector water per minute are being passed through the machine. The compact design and the remarkable accessibility of the plant is worthy of comment. Meters and orifices of several different sizes are carried on the trailer, so that any range of feed required, from 1 lb. of chlorine per 24 hours to 300 lb. per day, may be obtained, and the injectors will operate against any pressure from zero to 100 lb. per sq. in.

Sewage Treatment and Water Recovery.—Appreciating the vital importance of rigid water conservation in Southern California if this region is to realize the fullest measure of development to which its natural advantages entitle it, the officials of the Los Angeles Department of Water and Power have been engaged, for nearly five years upon an investigation of the feasibility of reclaiming part or all of its sewage flow of 120 m.g.d. at present wasted into the ocean. To better study methods of sewage treatment the department built an experimental activated sludge plant in Griffith Park. Theory indicates that in the biological reduction of sewage there is a division of work between bacteria and protozoans, and that unless the proper balance between these two groups is maintained the speed of reduction, and the character of the effluent, are adversely affected. It is known that if bacteria multiply beyond a certain point in any medium their further growth is inhibited by their own by-products. Consideration of these facts led to the hope that control of excessive bacterial growths in the various units of the treatment plant should improve the results. The Wallace and Tiernan Company kindly supplied us with two manual control chlorinators for the experimental studies, and these have now been in use nearly a year. It has been found that chlorine is a real aid to the activated sludge treatment, affording better reduction with increased gas production from the sludge digestion tanks.

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Water Consumption of New York City.—In 1929 the average daily consumption of water in New York City was 940 million gallons, including 60 million gallons daily from private sources in the Boroughs of Brooklyn and Queens. During 1930 the total consumption, also including the supply from private sources, increased to 995 million gallons per day. In addition to the above consumption within the city, 20 million gallons daily were supplied in 1930 to various communities outside the city, making the total average daily draft upon all of the available water resources during the past year 1,015 million gallons. The total available yield of all municipal and private sources of supply is 1,100 million gallons per day.

Central Alarm System for Sewage Pumping Stations

By Amos Clark

The topography of Plainfield, N. J., is more or less flat with six brooks dividing the city into as many watersheds, each of them having a very small slope and changing the average elevation of the city but slightly. The area of the city is approximately 6 square miles, and the sanitary sewers of two-fifths of this area drain to sewer pumping stations, one alongside of each of the above mentioned brooks.

About three years ago, four of the pumping stations reached a point, due to the rapid development of their drainage areas, when a failure of the machinery for a brief period resulted in the backing up of sewage in the cellars of a few houses nearest the stations. Check valves on the house connections proved of no value so the only solution was to be sure that the stations functioned continuously. The only way to be sure of that was to have them all connected with an alarm system at some central point. The only central point having night and day service was the police station.

We made arrangements with the telephone company for rental of their wires, two from each station. The total cost per month for the four stations covering a length of six miles is $25.00. The city installed all switches, floats and other control apparatus, laid all underground conduits between the streets and the pumping stations, the total cost of which was less than $2,000.

The apparatus in some of the stations consists of a pressure switch and in others a float switch, both being connected to a junction box containing switches and fuses, as required by the telephone company. We intend very soon, where the stations are operated by air, to have the alarm thrown on by both an air pressure switch and a float switch as now a situation might arise whereby with only one switch in use, a station might not be functioning properly while the alarm would not be on.

In the central point or police station, we have a large light which reflects upon the alarm switchboard. The light is an ordinary 60-watt lamp, operated by the house current, and is switched on by the relays in the switchboard. These relays also actuate the small lights on the face of the board, a light appearing just above the name of each station. Just below is a push switch by which the large light may be switched off but the smaller lights left on until the station is cleared. All of this apparatus operates on a very low voltage and amperage. Everything from the pumping station to the police station operates on the 24-volt current supplied by the telephone company, and everything within the police station operates on lighting current supplied by the city.

For the first two or three months after the system was installed we had a little trouble with the telephone company's repair men testing out the wires, but this was soon remedied for as soon as the men understood our system and labeled the wires we had no more trouble. This difficulty could be eliminated entirely and I think the system would be more positive if we could install a closed circuit system. The cost of such revision would be very small.

Acknowledgment.—The foregoing is abstracted from a paper presented at the 16th annual meeting of the New Jersey Sewage Works Association.

View of Sewage Disposal Plant from Top of Chlorine House

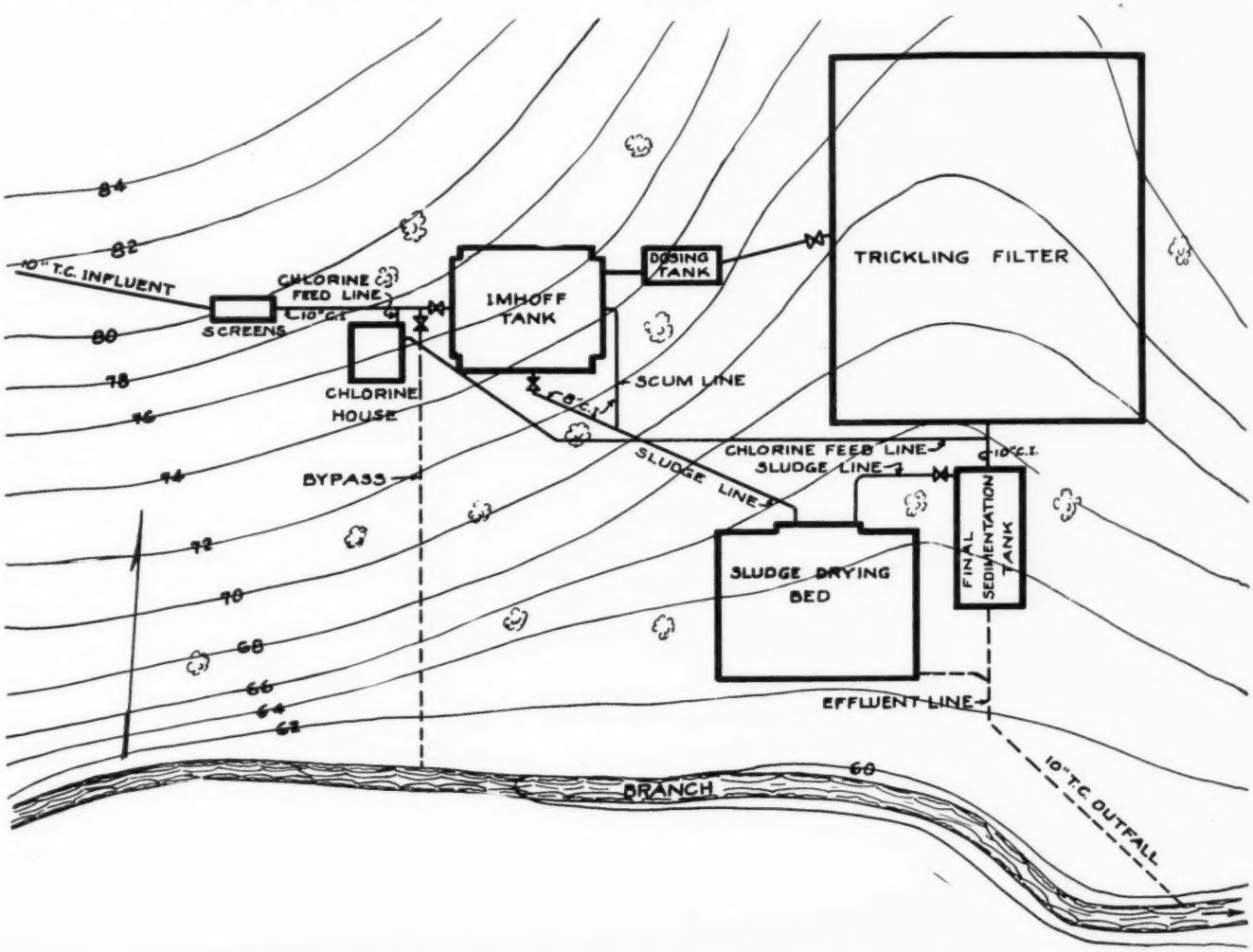
AN UP-TO-DATE SEWAGE DISPOSAL PLANT AT SWEET BRIAR COLLEGE, VA.

By W. MARTIN JOHNSON
Sanitary Engineer,
Wiley & Wilson, Consulting Engineers,
Lynchburg, Va.

THE campus at Sweet Briar College for girls is situated in the foothills of the Blue Ridge Mountains on a divide between three main natural drainage areas. The streams flowing from two of these areas form Rutledge Creek, a tributary of the James River, the third flowing into Rutledge Creek several miles below the college property.

Since the founding of the college in 1906 the sewage has been disposed of by means of three shallow septic tanks. The severe drought of 1930 reduced the natural stream flow of the branches through college property to such a point that the effluent of sewage was a major part of the flow in the streams. This condition caused odors along the streams, as well as sludge deposits and oxygen depletion indicating the presence of sewage in Rutledge Creek for some distance below the college.

With conditions as noted above, the State Board of Health recommended that modern treatment methods be employed to relieve the situation. At a meeting of the Board of Trustees in February, 1931, Wiley & Wilson, Consulting Engineers, of Lynchburg and Richmond, Va., retained by the college on all engineering work, were authorized to proceed with plans for a complete plant.



General Layout of Sewage Disposal Plant for Sweet Briar College, Sweet Briar, Va.

Screen Chambers in Foreground, Chlorine House to Right and Imhoff Tank Just Beyond

Plans and specifications were completed and bids taken for a complete gravity sewerage system and sewage disposal plant. Contract for the work was awarded to Craighill & Showalter, of Lynchburg, Va., who were low bidders. The plant was completed and placed in operation about Aug. 15, 1931.

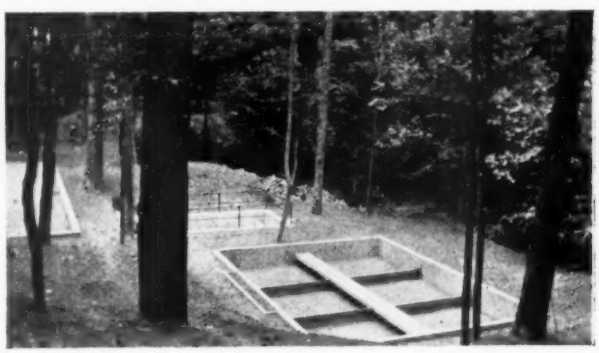
Sewer System.—The sewer system consists of approximately 7,000 ft. of new collecting lines of 8 and 10 in. pipe. An 18 ft. cut through one hill was necessary to eliminate pumps and obtain a complete gravity system. The main trunk sewer crosses a stream by means of cast iron pipe on concrete piers, to join the shorter line before entering the plant. The new plant treats the entire amount of sewage from all of the college buildings.

The disposal plant is located on a hill-side having a southern exposure in a wooded section of original growth timber. In locating the plant and pipe lines it was the desire of the college officials to leave uncut all trees and to disturb them as little as possible. The different units of the plant were located without damaging valuable trees. The grounds are graded around the units and small shrubbery is to be planted and the entire plant surrounded by a chain link fence.

The Plant.—The sewage enters the plant through a 10 in. terra cotta line directly onto a sloping bar screen, the screen chamber being provided with a sump for collecting grit. The screenings are raked onto a drying rack before being disposed of. The entire screen chamber is covered with fly screens mounted on movable frames to eliminate any possible fly nuisance. The sewage from the screen chamber flows directly into the Imhoff tank which is approximately 22 ft. square and 24 ft. deep. Concrete covers are provided over sedimentation chambers with sufficient openings of steel plate covers to permit easy cleaning down of the sloping walls with squeegees. The gas vents are provided with hinged wire mesh covers which permit the escape of gases and allow accessibility in pushing down the scum. The tank is designed for a large sludge storage so that a well digested sludge can be drawn on the drying beds. Baffles are provided at the inlet end of the sedimentation chamber. A scum board and ¼ in. mesh wire screen just ahead of the outlet weir protect the siphon chamber and nozzles from clogging.

The tank effluent is collected in a dosing tank provided with an 8 in. Miller sewage siphon, and counter for recording the sewage flow. This tank is also covered with concrete slab and steel plate manhole covers.

The dosing tank discharges through a field of type "D" Pacific Flush Tank nozzles fed through cast iron mains and laterals which are beneath the surface of the bed. The nozzles discharge on to a filter bed media of 1½ in. to 2½ in. crushed quartzite stone, all fine stone and soil having been washed out. The applied sewage filters through 6 ft. of this stone to the underdrainage system of vitrified terra cotta tile resting on a concrete floor. Provision is made in the bed for flooding it when necessary for fly control.



Edge of Trickling Filter Bed at Left, Final Sedimentation Tank at Rear and Sludge Drying Bed in Middle Foreground. Note the Natural Advantages as Well as the Beauty of the Location

The filter effluent passes into a final sedimentation tank where the remaining suspended matter is settled out before passing to the outfall line to the stream.

The digested sludge from the Imhoff tank and humus from the final tank can be drawn by gravity onto the sludge drying bed. The filter media of the drying beds consists of coarse crushed stone at the bottom and in successive layers above of fine stone, gravel and coarse sand. Drain tile laid on a concrete floor and placed 4 ft.

on centers provides drainage to the outfall line. The walls of the bed are of concrete. The bed is divided into three sections and provided with a concrete runway above the sludge level for wheelbarrows. The walls are standard size for a greenhouse cover should it become necessary to install one for any reason.

Solution feed chlorination is provided for by the use of a Wallace & Tiernan MSV vacuum type chlorinator having two-way feed device. One line feeds chlorine into the sewage just ahead of the Imhoff tank for odor control, the other just ahead of the final tank for bacteria control. The chlorinator is housed in a small concrete and brick building near the Imhoff tank. Double doors and windows together with "Celotex" sheeting and plastered ceiling and walls, provide good insulation for the house. An oil brooder-heater supplies heat in the colder months. A work bench is provided in the chlorine house for the operator to use in making residual chlorine and other tests about the plant. The chlorine cylinder rests on a scale platform.

The plant is designed for 150,000 g.p.d. treatment and was built at a cost of about $15.00 per capita; on the basis of 1,000 persons using the plant.

Laboratory equipment is provided for obtaining residual chlorine, pH., settleable solids and relative stability tests. These tests will be made daily and results kept on printed record sheets, and in addition, such data as quantity of sewage treated, chlorine and lime used, sludge depth and quantity drawn is also recorded.

The plant is in keeping with the high standards maintained by the college in all of its departments.

▼

State and Municipal Bond Election Results During October

New state and municipal bond issues approved by the voters of 47 municipalities in 23 states during the month of October totaled $230,433,000 as compared with $4,136,500 in October, 1930, according to *The Daily Bond Buyer* of New York. The huge total last month is largely accounted for by the $220,000,000 authorization by the taxpayers of the Metropolitan Water District of Los Angeles, Cal. Omitting this figure, the balance of $10,433,000 is comparable to October totals for other years, $4,136,500 in 1930; $21,805,600 in 1929; $12,096,600 in 1928 and $12,017,500 in 1927.

The only other large authorizations last month were $2,300,000, Oakdale, Cal., Irrigation Dist.; $1,146,000, Sacramento, Cal., Sch. Dist., and $1,145,000, Scarsdale, N. Y., Union Free Sch. Dist. No. 1.

The following table, compiled by *The Daily Bond Buyer,* presents a comparison of bonds approved by months for the past three years:

	1931	1930 (.000 omitted)	1929
January	$ 8,326	$ 11,620	$ 26,950
February	48,300	17,861	13,309
March	46,610	33,741	22,154
April	17,587	45,325	37,963
May	68,818	56,823	61,882
June	10,489	13,414	53,711
July	12,367	14,628	35,895
August	4,041	3,369	16,540
September	4,706	8,590	85,308
October	230,433	4,136	21,760
November	.....	405,976	48,499
December	.....	10,461	17,002
Total	$451,703	$626,059	$420,995

Seventh Annual Meeting of the Missouri Water and Sewerage Conference

The Seventh Annual Meeting of the Missouri Water and Sewerage Conference, held in Jefferson City on Oct. 22 and 23, 1931, provided an unusually attractive program consisting of papers and discussions on subjects of interest to water works and sewage treatment plant superintendents. Eighty-two men registered before the close of the conference.

Papers and discussions relating to water treatment were given by the following persons: William J. Gray, Consulting Engineer, Springfield; W. B. Rollins, Consulting Engineer, Kansas City; Judge Milton R. Stahl, Chairman, Missouri Public Service Commission; L. O. Williams, Jr., District Public Health Engineer, El Dorado Springs; A. G. Fiedler, U. S. Geological Survey, Washington, D. C.; Dr. H. A. Buehler, State Geologist, Rolla; H. S. Hutton, Wallace & Tiernan Company, Newark, N. J.; Herbert Bosch, State Board of Health; W. Scott Johnson, State Board of Health; and E. E. Wolfe, Hannibal.

Papers on sewage treatment were given by G. R. Scott, of Black & Veatch, Consulting Engineers, Kansas City; R. E. McDonnell, of Burns & McDonnell Engineering Co., Kansas City, Mo.; Geo. S. Russell, of Russell & Axon, Consulting Engineers, St. Louis; and, H. C. Delzell, of the Portland Cement Association, Chicago, Ill.

For the first time in the history of this organization, an entire afternoon was devoted to informal round table discussion of various problems. The results of this session were very gratifying, and it is probable that more time will be devoted to this phase of the program in future meetings.

Following an inspection trip of the Capital City Water Company's filtration plant on Friday, October 23rd, the members of the conference were served a luncheon at the plant by the water company. The annual dinner on Friday night was presided over by Dr. James Stewart, State Health Commissioner, as toastmaster. After the banquet, the ladies attended a theatre party and the men a smoker. On Saturday, a number of the members motored to Bagnell for the purpose of inspecting the hydro-electric project recently completed by the Union Electric Company at that place.

At the business meeting, the following officers were elected for the ensuing year: Chairman, E. E. Wolfe, City Chemist, Hannibal; Vice-Chairman, W. E. Barnes, Supt. Water Works, Liberty; Secretary-Treasurer, Herbert Bosch, Assistant Public Health Engineer, State Board of Health, Jefferson City. Executive Committee: A. V. Graf, Chief Chemical Engineer, St. Louis Water Department, St. Louis; L. W. Helmreich, Manager, Capital City Water Co., Jefferson City; M. S. Hogan, Supt. Water Works, West Plains, Mo.; A. E. Thain, Supt. Water Works, Neosho.

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Milk-Borne Typhoid Epidemics in Illinois.—According to a recent issue of the *Illinois Health Messenger,* a publication of the State Health Department, 17 milk-borne epidemics resulted in 288 cases of typhoid fever during the decade 1920-29. During the same period six water-borne outbreaks resulted in 437 cases of typhoid fever. More cases were involved in the water-borne outbreaks because the polluted water was used by more persons than was the contaminated milk. Milk was responsible for the transmission of several outbreaks other than typhoid.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

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THE USE OF CHARCOAL AND ACTIVATED CARBON IN WATER TREATMENT

Part 2: Characteristics of Activated Carbon

THE early history of the use of animal and vegetable charcoal was reviewed in Part 1. It was stated that carbons used years ago were not very active and had very little adsorptive capacity. It is believed advisable to define the terms "adsorption" and "activated carbon," as they will be used many times in the article.

Adsorption consists of the adhesion of molecules of gases or dissolved substances to the surface of solid bodies, resulting in a relatively high concentration of the gas or solution on the surface. Absorption is a more general term and does not imply that there is a chemical action or chemical adhesion of the compounds absorbed as is the case for adsorbed compounds. The distinction between adsorption and absorption may be more appropriately defined in that adsorption is the formation of a layer of molecules attached to or attracted by a solid surface of some other material, in contrast to the absorption of one substance into the interior of another. Most every one with a fair knowledge of chemistry is aware that certain solids have the power of drawing other compounds to their surface. Being largely a surface phenomenon, the amount of the compound that may be adsorbed will depend largely upon the surface area.

A true solid 1 in. in diameter has a certain surface area, and only a very small percentage of the molecules that go to make up the solid are exposed on the surface. The amount such a solid could adsorb is such a small percentage of the total weight of the solid it probably could be barely detected with the most sensitive testing devices. If the many million of molecules that formed the solid 1 in. in diameter were arranged into an irregular meshwork of fibers which are only a few molecules in diameter with the openings between the fibers large enough for water or air to pass freely through the meshes, the volume would be many times greater than the solid and the surface area would be increased perhaps millions of time over the surface area of the compact solid. The attachment of a layer of molecules to this expanded surface would be an amount that may be readily measured. Charcoal probably is not so greatly expanded as the condition assumed, but the surface area is enormous. This is why adsorption, apparently insignificant for solid particles like grains of sand, may be considerable for porous materials.

Development of the Activated Carbons.—Activate is to make active, and an activated carbon is some carbonized material in which the atoms may have some special arrangement and in which the surface atoms have been freed or partially freed from adsorbed compounds by some special treatment. These carbon atoms, with one, sometimes two, and probably for a few molecules, three free valences, attract certain compounds to the surface and hold the molecules in the adsorbed state. In the ordinary carbonizing process, such as is used to make charcoal, only a very small percentage of the surface carbon atoms are capable of adsorbing other compounds. This may be due to the type of primary carbon formed, or to the carbon adsorbing compounds released from the carbonaceous material as it is heated.

Active carbon is believed to be formed whenever carbonaceous substances are carbonized in closed vessels at low temperatures. Because of its activity it is believed to become saturated with hydrocarbons during the process of formation. The process of removing the adsorbed hydrocarbons, if indeed the carbon has become saturated with such compounds, is called "activation." This is not a very good term due to its confusion with activated sludge in sewage disposal. There is no relation between the meaning of activation as used in sewage treatment and as used to define the making of a carbon that will have a high adsorptive capacity, and it is unfortunate that the word has now become so firmly fixed in both cases that it does not seem advisable to use some other word in one case or the other.

Not much attention was given to the development of carbons of high adsorptive capacity prior to the use of toxic gases in the World War, and all such materials used before the war were limited in their adsorptive capacity, with the possible exception of a material introduced on the American market from Holland about 1911, known as Norit. This material was invented by Sauer and Wijnberg, and while the process was kept secret, the material was identified by Tanner[1] as being made from birch wood.

With the exception of the sugar industry, only a very limited amount of charcoal was being used for industrial purposes 15 years ago. Such materials as were then available did not prove successful in water treatment, except for small filters. The construction of

Fig. 1.—Nuchar Plant No. 1 at Tyrone, Pa., of Industrial Chemical Sales Co., Inc.

large sand filtration plants in most cities having turbid or highly polluted water has largely eliminated the use of small filters. Bone char replaced vegetable charcoal in the sugar industry in the early part of the Nineteenth century, and it is only recently that vegetable carbons have again been given much consideration. The power of removing color from solutions with vegetable charcoal is believed to have been known as early as the Fifteenth century. Lowitz worked on wood charcoal in 1785, and it was used in an English sugar refinery about 1794. It was made use of in the refining of sugar until Figuier, in 1811, showed that animal charcoal was even more effective.

In the manufacture of bone char, clean bones of compact structure are crushed, treated with a solvent such as petroleum or naphtha to remove the fat, and they are then carbonized in cast-iron retorts. Charring is from 6 to 12 hours, it being better to char at a red heat for the longer period than a higher temperature for a shorter time. It is necessary that the temperature be kept low in the initial stages of the process. The carbon content of good bone char should range from 9 to 12 per cent. In some manner not definitely understood, the process of charring the bones usually produces a more active carbon than is produced with the vegetable carbons which have not been activated. Perhaps the hydrocarbons within bones are more easily driven off, or the mineral constituents of the bones help to make the carbon more active. At any rate bone char usually has better decolorizing power than ordinary charcoal which has not been activated.

What is now known as activated carbon did not come into use until about 1916 or 1917 during the World War as a means of defense against poisonous gases. There was great demand for materials of high adsorptive capacity and preference was given to those that had the greatest adsorptive capacity per unit volume of adsorbent. This need not be the case for water works carbon, for preference should be given to materials that have the greatest adsorptive capacity for a given price. The matter of volume is immaterial, except where the granular material is used the granules should be fairly resistant to abrasion in handling and washing and have sufficient specific gravity so that they can be handled in beds without danger of floating away or being washed away. It is possible to hold the the lighter materials in a bed with screens, but usually this is not very satisfactory.

Classification of Vegetable Carbons.—Mantell[2] divides the vegetable decolorizing carbons into several classes according to the method of manufacture.

1. Carbon may be deposited as a layer on a porous inorganic base. Carbonizable vegetable materials such as sawdust, seaweed, peat and molasses, as well as other materials may be mixed with porous substances such as infusorial earth, pumice stone, insoluble salts, etc. The mixture is strongly heated, whereupon the vegetable matter is deposited throughout the porous base.

2. Carbon may be deposited on an inorganic base which is afterwards separated from the carbon by chemical means. Vegetable materials are mixed with chemical reagents such as lime, chalk, sulfuric acid, calcium chloride, zinc chloride, magnesium chloride, phosphoric acid, etc., and after carbonization the inorganic matter is dissolved out, leaving the resulting carbon. Zinc chloride, phosphoric acid, etc., function as activating agents. The presence of the inorganic substances during carbonization of the mixture prevents the formation of adsorbed films of inactive material which would cover the surface of the active carbon as occurs when the vegetable materials are carbonized alone.

3. Decolorizing chars are made by carbonizing materials such as lignite, waste pulp liquors, black ash residues, sawdust, woods and similar materials in carbonizing retorts under controlled conditions of temperature and atmosphere. Hydrodarco, Nuchar and Norit, the most extensively used materials in water treatment belong to this class. Hydrodarco is made from lignite, Nuchar from the waste products of paper mills, and Norit, as previously stated, from birch wood.

It might be said that all active carbons, with the exception of bone char, which are used to any material extent in industrial processes come under the third classification as given by Mantell. Coconut char and carbonized fruit pits also belong to this class of manufacture. All materials under class 3 require activation to produce a carbon of high adsorptive capacity.

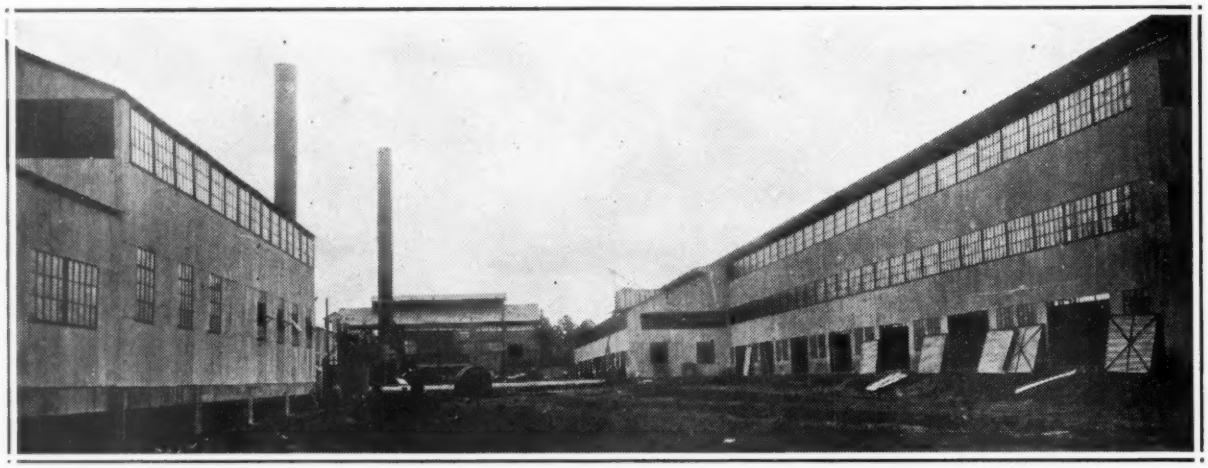

Fig. 2.—Plant of the Darco Corporation at Marshall, Tex.

Chaney[3] states that active and inactive carbon differ in two important particulars: (1) Temperature of formation, and (2) chemical activity, or susceptibility to oxidation. "The active modification is formed whenever carbon is deposited at relatively low temperature by chemical or thermal decomposition of carbon-bearing material; in general below 600 to 700° C. The inactive modification results from similar decomposition at higher temperatures; in general above 600 to 700° C. The active form is rapidly attacked by oxidizing agents. The inactive form is relatively stable towards oxidizing agents, resembling graphite in this respect."

Chaney believes that the temperature at which molecular carbon is set free is the controlling factor in determining whether it is of active or inactive variety. He believes that in the ordinary process of distillation of carbonaceous materials at relatively low temperature, active carbon is first formed by the thermal decomposition of unstable hydrocarbons. This active carbon adsorbs a quantity of hydrocarbons which are stabilized to a remarkable extent, so that they are retained under conditions of temperature, pressure, etc., at which they would otherwise be quickly eliminated as such or suffer decomposition. Chaney states that quantities of a hydrocarbon resembling anthracene, the boiling point of which is 350° C., have been isolated from cedar charcoal which has been previously calcined at 850°. This stabilized complex of hydrocarbons adsorbed on a base of active carbon is, according to Chaney, the product which is defined as primary carbon because it is the original product first occurring in low temperature carbonization of carbonaceous materials.

The Activation of Carbon.—If Chaney's theory of adsorption of hydrocarbons on the surface of active carbon in the carbonization of carbonaceous materials at low temperature is correct, then the activation consists in removing these adsorbed hydrocarbons from the primary carbon. When the carbon is heated to a very high temperature so as to decompose the adsorption complex, that is, to cause the hydrocarbons to be released from the primary carbon, it is released at a temperature much above the normal decomposition point of the hydrocarbons. The hydrocarbons then may break down and form inactive carbon that deposits on the surface of the active carbon. It has been stated that the formation of carbon below a certain temperature produces at least a part of the carbon in the active state or capable of being activated, and when formed above the critical temperature the carbon is largely inactive and cannot be made active. It is thus seen that the mere heating of a carbonized material will not produce carbon of high adsorptive capacity.

The hydrocarbon constituents of the adsorption complex appear to be slightly less resistant to oxidation than the active carbon, and by a proper adjustment of the temperature and concentration of the oxidizing material the adsorbed hydrocarbons may be removed. This requires some care, but when properly done very little inactive carbon is produced to cover the surface of the active material. The oxidizing agents used to the greatest extent are air and steam. Carbon dioxide and chlorine have been used to a limited extent.

Barker[4] believes that the mechanism of charcoal activation partly consists of converting the primary charcoal to graphite or graphite-like carbon of crystalline structure, and partly of increasing the interior surface area by producing a large volume of very small capillaries. The hydrogen and oxygen content of the charcoal is markedly decreased by activation and the true density of the carbon material increased from about 1.45 to 2.15.

There are various opinions as to the relative merits of air and steam for activation. Some believe when the reaction is exothermic (produces heat) the temperature is more difficult to control than when it is endothermic (absorbs heat). Hydrodarco is usually activated by the use of air, whereas steam is used in the activation of Nuchar. When air is used there is probably a direct oxidation of the carbon to form CO_2 or CO, and when steam is used, Thiele and Haslam[5] state that there are several possible reactions: (1) $C+H_2O=CO+H_2$. (2) $C+2H_2O=CO_2+2H_2$. (3) $C+CO_2=2CO$. (4) $CO+H_2O=H_2+CO_2$. These authors also state that it is well established that when oxygen or carbon dioxide reacts with carbon a surface complex of a very stable character is formed. This complex is usually represented as CxOy, which, in turn, breaks up into CO_2. They believe it is natural to suppose that a similar complex is formed when steam reacts with carbon, and since the complex is stable nearly all the surface will be covered with it.

There are several other theories as to how activated carbon is produced. It is believed, however, that the theory of Chaney comes the nearest to explaining experimental facts as found by a number of investigators.

Definitions of Terms Used in Testing Carbons.—It is evident that tests to determine the characteristics of carbon used in water treatment must soon come into use, and it will be necessary to make use of terms of which many are not now familiar. In so far as is pos-

sible it is believed best to adopt the terms already in use by those engaged in the manufacture and testing of carbon. The definitions defined will be the terms likely to be used in the testing of carbon in water treatment. These definitions are taken from the literature and seem to be the terms in most general use at the present time.

Apparent Density: The apparent density of carbon is the weight in grams of one cubic centimeter of the carbon. This is usually determined by weighing the carbon that will fill a 10 cc. cylinder graduate, the cylinder being tapped until the material shows no more settlement. In giving the apparent density the size of the carbon granules should be stated, such as 8 to 14 mesh carbon, 100 to 200 mesh carbon.

Granule Density: The granule density is the weight in grams per cubic centimeter of the material based on the volume of the individual granule.

True Density: The true density is the weight in grams of one cubic centimeter of the carbon substance exclusive of the voids or pores.

Porosity: The porosity is the percentage of the pore space in the carbon. In stating the porosity it should be stated whether for individual granules or the total pore space, which includes both the pores in the individual granules and the pores or voids around the granules.

Activity: The activity is calculated from the weight of the substance adsorbed by one gram of the carbon. The chloropicrin activity is the weight of chloropicrin adsorbed, the plenol activity is the weight of phenol adsorbed, the iodine activity the weight of iodine adsorbed, and so on, for compounds that may be used for testing the carbon.

The Surface Area of Charcoals and Activated Carbons.—It is difficult to conceive of the extremely porous nature of charcoal and the activated carbons. Attempts have been made to measure the surface area of such materials, and the figures obtained seem almost unbelievable. Some are of the opinion that adsorption ceases with the completion of a monomolecular layer on the surface. From the number of molecules adsorbed by a unit weight and the approximate dimension of one of the adsorbed molecules, the area is calculated. Garner, McKie and Knight,[6] using aliphatic alcohols estimated the internal area of a gram of charcoal to be 66 square meters. Taking the true density of charcoal to be 1.9, as determined by Cude and Hulet,[7] the carbon surface of one gram of charcoal is estimated by Garner, McKie and Knight to be composed of approximately 1.4×10^{21} carbon atoms. They also state that the total number of carbon atoms in one gram is 5.05×10^{22}, giving the ratio of surface atoms to total atoms as 1:36. Using 66 square meters as the surface area of one gram of charcoal, this would give for a cubic foot of the material weighing 10 lb. a surface area in excess of 3,000,000 sq. ft. Lamb, Wilson and Chaney[8] estimate that one cubic centimeter of active gas mask charcoal has a surface area of 1,000 square meters at the most effective apparent density of 0.4. This is a surface area considerably greater thant the charcoal estimated by Garner, McKie and Knight, and would amount to several square miles of area for a cubic foot of the carbon at the most effective density. Should these estimates of surface area be considerably in error it is still evident that the area is enormous.

In gas mask carbon it is desirable to obtain the maximum adsorption for a given volume of the material, and considerable attention is given the density of the carbon. It is desirable to have it as near the most effective density as possible. A variation either way from this figure results in less adsorption for a given volume of the material. A space entirely filled with carbon atoms would have no room for adsorbed molecules, whereas if the porosity approaches 100 per cent the mass of active carbon for unit volume approaches zero. Between these two extremes there is a certain density or porosity in which the maximum amount of active carbon per unit volume will be exposed. The most effective density given by Chaney, Ray and St. John is near 0.4.[9] It is evident that the size of the molecules to be adsorbed has something to do with the most effective density. Compounds with very large molecules might not be able to penetrate into the very fine pores.

Where carbon is used in water treatment in the powdered form it is believed that the material should be expanded as greatly as possible, and that a material with an apparent density of perhaps less than 0.15 is better than one at 0.4. Not only is the surface of the carbon more directly exposed to the water, but the lighter material remains suspended longer in the water than a denser material. Some consideration has to be given the density of the granular material, for the granules have to have sufficient strength so as not to wear excessively by abrasion in handling, and not to be crushed in beds due to the pressure of the water and overlying material. Granules of sufficient specific gravity to enable the beds to be washed as a sand bed is of considerable advantage. It may not be desirable for the material to have the most effective density as for gas mask material, though the apparent density probably should not be less than 0.2. Activated carbon made from lignite gives a very good density for use in the granular form.

Production of Activated Carbon.—Bone char is still the most extensively used carbon for adsorption purposes, being used most extensively in the sugar industry. The production of bone char in the United States is probably about 30,000 tons annually. It is evident that the meat packing plants are the main source of supply of bones. As stated in Part 1, bone char has been used to a limited extent in small water filters for about a century, though the amount used was almost insignificant compared with that used in the sugar industry. Good bones give about 60 per cent of char, but in crushing and screening there may be a loss of 20 to 25 per cent.

The largest plant for the production of activated carbon from lignite is that of the Darco Corporation, located at Marshall, Texas.[10]

Figure 1 is a photograph of "Nuchar" Plant No. 1, at Tyrone, Pa. Another Nuchar plant is located at Piedmont, W. Va. It has been stated that Nuchar is made from the waste products of paper mills.

Considerable Loss in Converting Carbonaceous Mate-

TABLE I—COMPOSITION OF MATERIALS USED FOR MAKING ACTIVATED CARBON

Material	Approximate Percentage of Material				Yield in Pounds of Primary Carbon per 2,000 Lb. of Raw Material
	Moisture	Volatile Matter	Fixed Carbon	Ash	
Coconut shells	4.5	74.9	18.9	1.7	555
Guava wood	7.1	72.8	19.3	.8	
Lignite, Texas	10.0	37.7	34.2	18.1	
Lignite, N. Dakota	19.6	33.3	41.2	5.9	
Bituminous coal					
Block bed, W. Va.	1.9	35.5	56.5	6.1	
Petroleum coke	1.0	6.5	90.3	2.2	1,820
Anthracite coal					
Jeddo, Pa.	3.8	3.4	89.8	3.0	1,960

TABLE II—LOSS IN DENSITY AND WEIGHT, AND INCREASE IN ADSORPTION BY ACTIVATION

Base Material	Apparent Density Primary Carbon	Apparent Density Active Carbon	Steam Treatment at 900° C. Time, Min.	Steam Treatment at 900° C. Weight Loss, Per Cent	Accelerated Chloropicrin Test Weight Adsorbed, Per Cent	Accelerated Chloropicrin Test Service Time, Min.
Sycamore	0.158	0.080	18	53	41	7.3
Cedar	0.223	0.097	60	88	78	16
Brazil nut	0.520	0.316	120	71	46	32
Coconut	0.710	0.445	120	60	61	58
Coconut	0.710	0.417	180	75	72	64
Briquetted materials						
Sawdust	0.542	0.365	120	66	53	40
Bituminous coal	.789	0.430	165	61	58.3	50.5
Anthracite	0.830	0.371	480	81	54	40.7

rials to Active Carbon.—There is considerable loss in converting any carbonaceous material to a primary carbon, except for materials low in volatile matter such as anthracite coal. This is especially true for materials high in hydrocarbons. The figures used in Table I are taken from Technical Paper 479, U. S. Bureau of Mines."

The loss in weight of the material in producing a primary carbon is shown by the table to be somewhat in proportion to the water and volatile matter in the raw material. After the primary carbon is produced there is considerable additional loss in activating. Table II, which is taken from Lamb, Wilson and Chaney,[8] shows that this loss is great if the activation is very long, though a more active material may be produced by the longer activation.

Table III shows the change in pore volume and adsorption resulting from activation as given by Barker.[4]

The results shown on the tables give some indication of the problems confronting the manufacturer in the selection of raw materials to use in making active carbon. One might conclude that the coals highest in fixed carbon would yield the largest amount of carbon for a given weight of raw material. This may be true, but the difficulty in making a very active carbon from anthracite coal and the high loss in activation has kept it from being used to any material extent. Fieldner, Hall and Galloway[11] state that the bituminous coals of Pennsylvania and West Virginia and certain Utah coals gave fairly satisfactory products for gas masks, but that the best and most active carbons were obtained from anthracite coals having the highest carbon content and lowest ash, volatile matter, and sulphur content.

(Part 2 will be continued in the next issue)

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TABLE III—CHANGES IN PORE VOLUME AND ADSORPTION IN CHARCOAL UPON ACTIVATION

Charcoal	Adsorptive Power. CCl_4 per Gram of Charcoal, Milligrams	Granule Density	True Density Charcoal Substance	Volume per Gram Charcoal, C.C.	Charcoal Substance per Gram, C.C.
Primary coconut	47	0.96	1.46	1.04	0.685
Activated coconut	630	0.84	2.15	1.19	0.465
Primary ironwood	30	0.89	1.46	1.123	0.685
Activated ironwood	1160	0.72	2.15	1.39	0.465
Primary lignite	30	1.09	1.43	0.92	0.700
Activated lignite	640	0.89	2.15	1.12	0.465
Extremely activated lignite	2715	0.31	2.15	3.23	0.465

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Bermuda to Have Ground Water Supply

The first fresh water system in the history of Bermuda will be open for public use on Nov. 30, according to Prof. W. D. Turner of the Department of Chemical Engineering at Columbia University, who planned and directed the construction. Drain water caught on the house tops and frequently polluted to a high degree, has served the residents of the island for generations.

In Bermuda most of the rock is of porous coral, filled with small cavities and fissures. After a survey of the island a small hill near Hamilton, capital of the colony was selected in the belief that the fresh water filtering through the rock crevices might be collected. A trench about 250 ft. long and 4 ft. deep was dug at the base of the hill. The bottom of the excavation was approximately a foot above sea level and sloped gradually to a pump pit.

A pipe line was laid in the trench with open joints so that water might find its way into the pipe and thence to the basin or pit. By concreting the basin, which, of course, was dug below sea level, sea water was prevented from seeping in.

From the collecting basin the water will be pumped into a new reservoir which is practically completed at Pymwood, near Hamilton. From that point the supply will be piped to the capital city and perhaps to St. George's, the old capital, 12 miles from Hamilton.

The capacity of the island system is 300,000 gal. The population of Hamilton is 6,000, but because of the conservative use of water in Bermuda it is expected the new system will more than meet the demand. The new water system, which will be known as the Bermuda Water Works, was financed by H. W. Watlington, philanthropist and a member of the House of Assembly. Construction work was started in the summer of 1930.

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EAST ORANGE, N. J., TO CONSTRUCT SUBSURFACE RESERVOIR.—Concluding that under an act of 1928 the proposal by East Orange, N. J., to construct a subsurface covered reservoir in Maplewood Township is "reasonably necessary for the service, convenience or welfare of the public," the Public Utilities Commission has granted the petition of East Orange for that purpose.

SYMPOSIUM OF PRACTICE

HOW FREQUENTLY SHOULD METERS BE READ AND BILL RENDERED

East Bay Municipal Utility District

The East Bay Municipal Utility District is a municipal corporation of the state of California, operating under an act of the state legislature. It is located on the continental side of San Francisco Bay. Within its boundary lines are nine municipalities: Richmond, El Cerrito, Albany, Berkeley, Emeryville, Piedmont, Oakland, Alameda and San Leandro. The population of the nine municipalities is over 500,000. From Richmond on the north to San Leandro on the south these nine municipalities have built up against each other to such an extent that generally some street is dedicated as the boundary line.

The Utility District operates independently of the cities within its boundary. The municipal governments are customers of the district. The distribution system has been built and is operated to serve the entire population of the district as one city. Business offices for the convenience of consumers are maintained in the cities of Oakland, Berkeley, Alameda and Richmond.

The district has in service over 130,000 meters. All services are metered. The meters are read and bills rendered for a 30-day period. For the purpose of reading, the meters are grouped into serials. There are 24 serials read during a calendar month. A serial represents one day's work, consisting of about 14 meter books for a foreman and 13 meter readers.

Commencing on the first business day of each month approximately 5,500 meters are read daily, Sundays and holidays excepted, and corresponding bills prepared and mailed. The bills prepared in the serial read on the first business day of the month are the charges for service rendered from the first of the preceding calendar month. Thereafter, the serial read each business day is for a 30-day period of service, i. e., from the 2nd to the 2nd, 3rd to the 3rd and so on. The schedule of reading dates varies slightly from time to time on account of Sundays and holidays.

Most municipally and privately owned water works operate under laws and state regulations that require close supervision of all services and frequent contact with the consumers regarding the service rendered and the collection of the charges for the service. The constant changing of consumers, both property owners and tenants, i. e., moving in where the service has been turned off and turning it on without notice; moving out and another consumer moving in and neither notifying the utility, necessitates a frequent reading of the meters and rendition of bills. It is only on the date of the reading of the meter or when the bill is rendered that the utility learns of these changes. Furthermore, a large majority of the consumers who move out without notifying the utility have established their credit and withdrawn their guarantee deposits. It is under such conditions that the East Bay Municipal Utility District operates. Therefore, the district reads its meters and renders bills to its consumers every 30 days.

An ideal situation would be where a water works is city owned and the law such that the city recognized no one but the property owner. This would permit of the service always being turned on. The property owner to keep all water equipment on the premises in good condition. Any unpaid charges for service would become a lien on the property, the same as unpaid taxes. Under such conditions meters could be read semi-annually. When property changed hands between meter reading dates the charge would be prorated between the seller and the purchaser in the same manner as an adjustment of taxes is made. But few water works operate under such favorable conditions.—F. W. Hanna, Chief Engineer and General Manager, East Bay Municipal Utility District, Oakland, Calif.

Grand Rapids, Mich.

In the case of meters 2 in. and larger, the meters are read monthly, these readings being used as a check on the accuracy of the meter and thus showing any trouble immediately. It has been our experience that this monthly reading of larger meters often brings troubles to our attention which would otherwise run for a three month period.—Carl H. Grinnell, Superintendent of Water Works, Grand Rapids, Mich.

Hagerstown, Md.

The Water Department reads meters and collects monthly on all large consumers and quarterly on all private consumers. We think this is the best method as large meters are more likely to go wrong than small meters and should be read monthly.—Albert Heard, Superintendent Water Department, Hagerstown, Md.

Lincoln, Neb.

Meters should be read and bills rendered once each month. Leaks may develop on customers appliances and fixtures which might cause an excessive bill if left for a longer period of time.—B. P. Hallock, Division Superintendent in Charge Water, Gas and Electric Operation, Illinois Public Utility Co., Lincoln, Neb.

Carbondale, Ill.

We read and bill all our customers once a month. This practice discovers any leaks at once, gets us the money sooner, and keeps us in line with the telephone, gas and power companies, which follow in same practice. We are 100 per cent metered.—C. S. Gill, Superintendent, Water Works, Carbondale, Ill.

Capital City Water Co.

We believe that reading water meters monthly saves considerable loss to consumer, due to leakage, leaky fixtures, etc., because our meter readers are asked to determine whether there are any observable leaks, and if any are found the customer is notified. Likewise if a meter registers considerably higher one month than the other the meter reading is checked on the premises and the listening device is used to determine a leak, if any.—L. W. Helmreich, Vice-President, Capital City Water Co., Jefferson City, Mo.

Waukesha, Wis.

Our commercial billing which takes in all ⅝ in. and ¾ in. meters are billed every three months and are read once in three months. This quarterly reading and billing serves for two purposes: it enables our department to divide the city into four sections and by doing so we can take care of billing and collecting with less help in the department. All meters 1 in. and larger go on the industrial rate which is slightly cheaper and these are read and billed each month. This I believe is done in nearly all water departments, except possibly in small villages where they only have a couple hundred customers all told. In cities where the number of meters run around 4,000 to 6,000 it is all one meter reader can do to properly read and take care of same on the basis as we are working, also it keeps our billing department busy when it is handled by only two men and these men take care of all collections as well. One must study all conditions under which a water department is operating before stating how frequently meters should be read and bills rendered. But I am of the opinion that small villages can have all meters read and bills rendered once a month providing they adopt the latest methods which we have found speeds up our work about 50 per cent or better.—James F. Hamilton, Superintendent, Water Department, Waukesha, Wis.

Conneaut, O.

We read all industrial meters monthly. Domestic consumers quarterly, and bills are rendered at the time of reading. Our town is divided into three sections which are read numerically. This allows collections monthly. Our reasons for reading the larger consumers monthly is that we avoid having meters out of order and we also have the money from our sales of water regularly so that all discounts can be taken on bills.—Lee Harvey, Superintendent of Water Works, Conneaut, O.

Plainfield-Union Water Co.

Factory meters and other large meters are read monthly; ⅝ in., 1 in., 1½ in., and 2 in. meters are read quarterly. We have the continuous reading system. We serve 18 cities and so divide them that when one section is read and billed the men move to next section and go right on. We use utility billing machine and bill the day after meter is read.—Geo. M. Haskew, Superintendent and Engineer, Plainfield-Union Water Co., Westfield, N. J.

Tallahassee, Fla.

Our meters are read monthly between the 15th and 20th of the month, so that bill may be rendered on the first.—Wm. R. Galt, City Manager.

Wauwatosa, Wis.

We read water meters every month but bill the consumer every three months. The reason for reading the meters every month is to check leaks in the plumbing that the consumer is unaware of until the meter reader reports same. He also discovers meters that are out of order so that they can be repaired at once. We find that this has worked out very satisfactorily and has in some cases benefited the consumer by finding the leaks in the plumbing.—A. W. Hebbring, Superintendent of Water Works, Wauwatosa, Wis.

Davenport, Iowa

It is our practice to read and bill all industrial, commercial and municipal meters monthly. Domestic meters are read and billed once in each three months. One-third of the domestic meters are read each month and the territory is divided into three districts for this purpose. This plan is satisfactory.—Charles R. Henderson, Manager, Davenport Water Co., Davenport, Ia.

Holyoke, Mass.

For all users of large amount of water, such as mills, the meters are read and bills rendered monthly. For apartment blocks meters are read monthly and bills rendered quarterly. Residences are not metered.—Patrick Gear, Superintendent of Water Works, Holyoke, Mass.

Hartford, Conn.

The following note is abstracted from the 77th report of the Board of Water Commissioners of Hartford, Conn., covering the 6 months period ending June 30, 1930:

The meter reading force consists of an assistant foreman and six readers. The assistant foreman acts in the absence of the chief clerk.

The territory is divided into seven zones of which readings are taken every other month and billed semi-annually—the 7th zone comprising the larger meters, being read and billed monthly. Each reader averages about 90 meters daily.

Zone No. 1 is billed in Feb.	and Aug.	—Averages 3,494 Meters
Zone No. 2 is billed in Apr.	and Oct.	—Averages 3,411 Meters
Zone No. 3 is billed in June	and Dec.	—Averages 4,264 Meters
Zone No. 4 is billed in Mar.	and Sept.	—Averages 3,875 Meters
Zone No. 5 is billed in May	and Nov.	—Averages 4,395 Meters
Zone No. 6 is billed in Jan.	and July	—Averages 3,174 Meters

Each zone is placed in the mail the last day of the month and is due and payable the first day of the month following. On all water bills remaining unpaid twenty days after due a penalty charge of 5 per cent is added until the first of every month thereafter, when an additional 1 per cent is added to the 5 per cent until paid. The first of the following month after the bill is due a delinquency notice is forwarded to the owner of the premises, with a request to pay within five days. After this period, the account is turned over to the collector who gets in communication with the tenants occupying the house giving them an opportunity to pay the water charges, they in turn deducting the amount from their monthly rental. If the collector is unsuccessful, the water is shut off. Before the water is again turned on, all back charges must be paid plus a $2.00 fee for the service.

TRICKLING FILTER LOADINGS*

By B. F. HATCH
Assistant Engineer,
Ohio State
Department of Health

IN connection with the design of a trickling filter, the filter load may be expressed in pounds of oxygen requirement per 1000 cu. ft. of filtering material. This method of expression of filter loading at once takes into consideration both the gallonage and concentration of the applied waste. It is a yardstick calibrated in terms of the actual ability of a trickling filter to supply the oxygen required to modify the organic matter contained in the applied waste to a more stable form. It seems to the writer that such a yardstick for measuring filter loadings might well be used for all industrial wastes of an organic character and for domestic sewage.

Present Loading Expressions.—At the present time it is common practice to express trickling filter loading in terms of population per acre or per acre-foot and in terms of gallons per acre or per acre-foot. However, there seems to be considerable difference of opinion among sewage treatment experts as to what the loading limits should be according to these yardsticks. Obviously, the sewages of different localities will vary in gallons per capita per day and hence in concentration. However, unless industrial wastes are predominant and seriously affect the character of the sewage, the actual pounds of organic matter per capita per day, as measured by the 5-day biochemical oxygen demand test, should not vary markedly. Therefore, unless the sewage from one city is more readily oxidizable than that from another, due to the influence of industrial wastes, the population loads should be fairly uniform. As a matter of fact in most municipalities industrial wastes do influence the character of the sewage to a considerable degree and it has become the practice to express the strength of such wastes in terms of equivalent population. Due to the complexity of many industrial wastes this method of expression is subject to a number of influencing factors and at best is hazardous in its application. Whatever the cause may be the fact remains that the designed population and gallonage loads of various trickling filters constructed in Ohio in recent years have varied widely. In Table I are given the essential design data on loading for the trickling filters of several Ohio sewage works.

Proposed Loading Expressions.—Instead of population load per acre or per acre-foot and gallonage load per acre or per acre-foot as now used, it is suggested that the expression of filter loading be made in terms of pounds of oxygen requirement of the applied sewage per 1000 cu. ft. of filtering material or per acre-foot. If pounds of oxygen requirement per unit of filter volume is used as a measure of filter loading it is then necessary only to consider the dosage rate, and in extraordinary cases the concentration load, to be assured that the design is in keeping with the ability of the filter to perform the task allotted to it. Ordinarily, with domestic sewage concentration loads and gallonage loads should fall well within the allowable limits. With certain types of industrial wastes, however, this may not be the case and it has been our experience with the treatment of milk wastes on trickling filters that concentrations of organic matter must be controlled, preferably by dilution, so that the B.O.D. of the applied waste does not exceed 400 ppm. if a stable effluent is to be produced. It will be necessary in cases of extraordinarily weak sewages that the dosage rates be checked so that they do not exceed the allowable limits. For instance, consider the following comparison: The sewage of one locality amounts to 50 gal. per capita per day and has a 5 day B.O.D. after sedimentation of 300 ppm. while in another locality the sewage flow is 300 gal. per capita per day and the 5-day B.O.D. of the settled sewage is 50 ppm. Obviously, the per capita organic load on the two trickling filters in this instance would be 0.125 lb. in each case. Hence if the same oxygen requirement load factor were used in both instances, the dosage per acre in one case would be six times that in the other. The load which a trickling filter is capable of handling is without doubt affected by the speed of displacement of the interstitial liquid in the filter, or, in other words by the speed of travel of the applied sewage through the filter. Hence the dosage rate is an important factor in filter loading.

Allowable Loadings.—If pounds of oxygen requirement per acre-foot or per 1000 cu. ft. is to be used as a measure of filter loading the question immediately arises as to what the allowable load factor should be. The Engineering Division of the Ohio Department of Health has tentatively set a figure of 250 lb. of oxygen requirement of the applied sewage per acre-foot as the probable uppermost limit of trickling filter loading for continuous production of a stable effluent. This corresponds to a load of 5.83 lb. of oxygen requirement per 1000 cu. ft. of filtering material. These figures roughly correspond to the old expressions of loading of 2500 persons per acre-foot and 250,000 gal. per acre-foot i. e., 1.5 m.g. per acre of 6 ft. depth. In this regard it may be of interest to review the operating results at several Ohio plants during the last few years. In Table II are given the pertinent portions of the operating data for the trickling filters of the various plants while in Table III the loadings and performances are indicated. A study of these data seems to indicate that if a stable effluent is to be produced a filter loading of 5.83 lb. oxygen requirement per 1000 cu. ft. of filtering material cannot be safely exceeded.

Summary.—It is not the purpose of this paper to sug-

TABLE I—DESIGNED LOADINGS FOR TRICKLING FILTERS OF SELECTED OHIO SEWAGE TREATMENT WORKS

City	Total Area Acres	Ave. Depth Feet	Population Designed for	Population per Acre Ft.	Dosage per Acre, Mgd.	Dosage per Acre Ft., Mgd.
Akron	14.0	10	260,000	1,860	2.35	0.235
Alliance	1.26	10	36,000	2,860	4.3	0.43
Canton	6.75	7	135,000	2,857	2.0	0.286
Cleveland, southerly	6.0	10	240,000	4,000	4.0	0.400
Columbus	10.0	5.33	200,000	3,750	2.0	0.375
Delaware	0.55	8	14,500	3,300	2.63	0.33
Fostoria	0.82	7.2	15,000	2,540	2.44	0.34
Marion	1.4	10.0	40,000	2,850	2.85	0.285

*Excerpts from paper presented before the Fifth Annual Ohio Conference on Sewage Treatment, Akron, O., Oct. 14, 1931.

TABLE II—OPERATING DATA FOR SELECTED OHIO SEWAGE WORKS, 1927-1931

Location	Operation Period Chosen	Average Sewage Flow mgd.	Population Served Thousands	BOD 5 Days 20°C. ppm. Raw	Settled	Filtered	Nitrates ppm.
Akron	July-Nov., 1929	23.67		134.6	121.2	14.4	2.74
	May-Oct., 1930	22.47	200	126.3	91.7	17.4	4.83
	May-Aug., 1931	29.08		161.3	114	19.5	2.61
Alliance	Aug.-Nov., 1929	2.157		214.3	158	31.1	5.5
	May-Oct., 1930	1.95	20	217	146	35.5	11.4
	May-July, 1931	2.267		199.7	144.7	39.3	10.3
Canton	May-Oct., 1927	6.8		204.5	123.8	26.5	
	May-Oct., 1928	7.3		192.7	115	23.9	11.0
	May-Oct., 1929	9.65	100	210.7	100.5	25.2	10.1
	June-Aug., 1931	9.6		198	117.7	25.9	9.1
Cleveland	May-Aug., 1929	6.28		144.5	67.2	27.0	8.74
	May-Oct., 1930	8.24	80	167.5	110.8	31.6	6.98
	May-July, 1931	12.43		151.7	96.3	27.3	7.3
Columbus	May-Oct., 1927	29.12		208.7	125.7	38.8	2.17
	May-Oct., 1928	30.77		203.7	133	56	1.72
	June-Nov., 1929	31.35		210.2	142.2	56.8	2.47
	May-Oct., 1930	31.5	320	230.3	153.8	64	1.38
	May-Aug., 1931	36.5		169.8	120.0	40.8	3.22
Delaware	Aug.-Nov., 1928	.388		345.3	308.3	35.1	8.73
	May-Oct., 1929	.474		298.5	215.1	32.1	14.1
	May-Oct., 1930	.368	9	358.3	269	31.4	20.3
	May-Aug., 1931	.401		324.7	243.5	29.4	14.05
Fostoria	June-Oct., 1928	1.761		134.6	73.6	27.2	
	May-Oct., 1930	1.413	12.5	202.5	124.8	29.7	5.1
	May-Aug., 1931	1.605		192	157.5	55.7	5.83
Marion	May-Oct., 1927	1.327		228.9	119.6	22.6	18.1
	May-Oct., 1928	1.221		288.4	172.6	26.9	16.5
	May-Oct., 1929	1.415		289.1	171.7	27.6	15.9
	May-Oct., 1930	1.40	24	302.2	189.2	31.7	16.1
	May-Aug., 1931	1.512		279.5	192.5	35.7	12.8

gest what trickling filter loadings should be but rather it is the purpose to point out certain facts which have been developed as a result of the operation of some of our Ohio plants. It is believed that there is need of further study to determine the influences of dosage rates and of varying concentrations of organic matter upon trickling filter performances. It is also believed that there is a fertile field for research work in determining what loadings of organic matter are allowable. In stating filter loadings the writer believes that the fundamental expression should be in terms of pounds of oxygen requirement per unit of filter volume.

TABLE III—TRICKLING FILTER LOADING AND PERFORMANCE AT SELECTED OHIO SEWAGE WORKS, 1927-1931

Location	Year	Filter Load Lb./Day*	Filter Removal Lb./Day†	Filter Efficiency Per Cent	Filter load Lb./Day Per Acre-Foot	Per 1,000 c.f.	Per Capita	Filter Removal Lb./Day Per Acre-Foot	Per 1,000 c.f.	Per Capita	Filter Load per Acre-Foot MGD	Persons
Akron	1929	23,900	21,060	88.1	170.8	3.92		150.5	3.46		.169	
Akron	1930	17,160	13,900	81.0	122.6	2.81	.0858	99.3	2.28	.0695	.160	1,428
Akron	1931	27,620	22,900	82.9	197.2	4.53		163.6	3.76		.208	
Alliance	1929	2,840	2,280	80.3	225.4	5.17		180.9	4.15		.171	
Alliance	1930	2,375	1,800	75.7	188.7	4.33	.1187	142.8	3.28	.0900	.155	1,587
Alliance	1931	2,730	1,990	72.8	216.6	4.98		157.9	3.63		.180	
Canton‡	1927	7,020	5,520	78.6	148.6	3.41		116.7	2.68		.144	
Canton‡	1928	6,995	5,540	79.2	148.1	3.40		117.2	2.69		.155	
Canton‡	1929	8,080	6,055	74.9	171.1	3.95	.0808	128.2	2.94	.0605	.204	2,116
Canton‡	1931	9,420	7,350	78.0	199.2	4.57		155.5	3.57		.203	
Cleveland	1929	3,520	2,110	59.8	58.7	1.35		35.3	.81		.104	
Cleveland	1930	7,610	5,440	71.5	126.8	2.91	.0952	90.7	2.08	.0680	.137	1,333
Cleveland	1931	9,980	8,150	71.7	166.3	3.82		135.8	3.12		.207	
Columbus	1927	30,480	21,060	69.1	571.9	13.13		395.2	9.07		.546	
Columbus	1928	34,080	19,720	57.9	639.5	14.68		369.6	8.48		.578	
Columbus	1929	37,150	22,300	60.1	696.8	15.98		418.3	9.61		.586	
Columbus	1930	40,350	23,550	58.4	757.5	17.38	.1262	441.8	10.14	.0736	.591	6,010
Columbus	1931	36,500	24,080	66.0	684.5	15.72		451.8	10.37		.685	
Delaware	1928	998	884	88.6	226.8	5.21		200.8	4.61		.088	
Delaware	1929	850	723	85.1	193.2	4.43		164.3	3.77		.108	
Delaware	1930	824	728	88.3	187.3	4.30	.0916	165.5	3.80	.0809	.084	2,045
Delaware	1931	814	716	87.9	185.0	4.25		162.7	3.73		.091	
Fostoria	1928	1,080	680	63.1	182.7	4.19		115.0	2.64		.298	
Fostoria	1930	1,470	1,120	76.2	248.8	5.71	.1176	189.5	4.35	.0897	.239	2,120
Fostoria	1931	2,110	1,365	64.6	356.9	8.19		230.8	5.30		.271	
Marion	1927	1,325	1,075	81.1	94.7	2.17		76.8	1.76		.095	
Marion	1928	1,755	1,480	84.7	125.3	2.88		105.6	2.45		.087	
Marion	1929	2,025	1,700	83.9	144.7	3.32		121.3	2.79		.101	
Marion	1930	2,210	1,840	83.2	157.8	3.62	.0921	131.5	3.04	.0767	.100	1,715
Marion	1931	2,425	1,975	81.4	173.3	3.98		141.1	3.24		.108	

*Based on 5 day B.O.D. of applied sewage.
†5 day B.O.D. of applied sewage minus 5 day B.O.D. of filter effluent.
‡1930 figures not used because copper contamination of dilution water gave low results.
Note: Loading, removal and efficiency are all expressed in terms of 5 day oxygen demands.

ACTIVATED CARBON FOR REMOVAL OF TASTES AND ODORS IN WATER*

By **F. H. WARING**
Chief Engineer, Ohio Department of Health

F. H. Waring
Chief Engineer
Ohio Department of Health

THE usual taste and odor producing substances in water are probably represented by organic matter in an incomplete state of decomposition. Unusual characteristics are caused by industrial wastes, especially those containing phenols. For the most part the naturally occurring taste and odor ingredients are largely volatile and oxidizable.

Use of Carbon for Purification Purposes Not New.—It has long been known that carbon in a simple form, like charcoal, possessed peculiar affinity for absorbing certain gaseous and liquid foreign substances present in minute quantities in a fluid. "Activated carbon" is the term applied to carbon that has been processed to render it more than usually active in its adsorption quality.

The idea of using carbon to assist in the purification of water by the removal of tastes and odors is not new. Recent revival of interest in its use is due largely to refinements in the preparation of the carbon and the perfection of a simple adaptation of applying the carbon in water treatment practice. Two prime reasons for present popularity of the idea are, (1) the widespread occurrence of bad tasting waters and a natural and insistent demand for better tasting drinking water. (2) It is no longer necessary to resort to expensive devices to employ the carbon for taste and odor removing purposes.

Results of Early American Researches.—Many years ago charcoal beds were employed at several European water works; and, according to the literature upon the subject, activated carbon in connection with sand filtration was used rather extensively by the Candy Filter Company of England at least 20 or 30 years ago. Careful research into the possibilities of using carbon in water purification work in this country was undertaken by J. R. Baylis[1] of the Chicago Experimental Filtration Plant in 1928. At about the same time the writer's attention was called by Mr. J. W. Ellms, to similar independent researches at the Cleveland Baldwin Filtration Plant[2]. Other early experimenters upon carbon treatment of water in this country were Messrs. Norcom and Dodd[3] at the Chester, Pa., plant treating Delaware river water and Messrs. Behrman and Crane[4] of the International Filter Co., Chicago, Ill.

These early experiments involved the use of carbon in granular form wherein the usual effluent from rapid sand filtration was passed through carbon beds of varying thicknesses. Either downward or upward flow units were used and the use of 30 in. beds at 2 gallon per minute rate was suggested. It was pointed out that the carbon treatment was particularly adapted for two general purposes: (1) The removal of chlorinous tastes, thus permitting generous rates of application of chlorine and insuring certain sterilization of water supplies, whether previously filtered or not, and obviating the necessity of varying the chlorine rate of application with the rate of pumpage which is peculiar to many small water works. (2) The destruction and elimination of other taste and odor ingredients by first employing superchlorination followed by removal of the excess chlorine by passing the final effluent through the carbon beds. It was recognized that direct absorption of the taste and odor ingredients was feasible, but the preferred procedure embraced heavy chlorination followed by carbon treatment rather than the reverse.

As a result of this early work many industrial installations have been made especially at bottling works, such installations usually employing pressure filter devices equipped with granular carbon instead of sand. Municipal installations of this type with one or two exceptions have not generally been made, largely because of the very considerable first cost of the equipment. Furthermore it has been found difficult to provide such treatment in conjunction with an already existing water treatment plant. Behrman[5] however, has estimated that the special design of hydrodarco carbon treatment units might be included in a new 10 mgd. capacity filtration plant for approximately $50,000 more than the cost of the filter plant alone.

Use of Powdered Activated Carbon.—The application of activated carbon in municipal water treatment received considerable impetus following the introduction of an entirely novel means of providing the necessary contact of the carbon with the water as conceived by G. R. Spalding at the Hackensack, N. J., filtration plant.

Early in 1930 laboratory tests at the South Pittsburgh, Pa., water softening plant revealed success from the use of relatively minute quantities of activated carbon in powdered form applied to the water. Subsequently in October, 1930, the application of powdered activated carbon to the raw water was conducted on a plant scale successfully to combat phenolic tastes and odors during an interval of accidental spill at a by-product coke plant into the Monongahela River above the plant.

The carbon used in the South Pittsburgh instance

*Abstract of a paper read Oct. 8 before 33rd Annual Meeting of Central States Section, American Water Works Association, at Cincinnati, O.

[1]Jour. Am. W. W., June, 1929; Jour. Am. W. W., Nov., 1930.

[2]Unpublished report to Cleveland Water Department.
[3]Jour. Am. W. W., Nov., 1930.
[4]Jour. Am. W. W., Nov., 1930.
[5]Jour. Am. W. W., Nov., 1930.
[6]Public Works, June, 1931.

was "Nuchar"—an activated carbon pulverized to pass a 200 mesh sieve—which is produced by the Industrial Chemical Sales Corporation, Tyrone, Pa. This company immediately prepared to furnish carload lots not only to South Pittsburgh but to certain other water works plants owned and operated by the American Water Works & Electric Co.[5] The success of the treatment was unquestioned.

Early in December, 1930, and again in March, 1931, the Ohio River Board of Engineers (comprising the chief engineers of the State Health Department in the eleven Ohio River states) met in Cincinnati to consider steps to be taken to combat ill effects of the prolonged drouth, especially upon public water supplies. One of the principal recommendations of this board was that every Ohio River filtration plant should be equipped for both the ammonia-chlorine treatment and activated carbon treatment in order successfully to cope with possible phenolic or other taste producing substances present in the Ohio River water.

Many water works have therefore recently installed powdered activated carbon treatment either permanently or are equipped to employ it during future occurrences of tastes and odors. Such installations are not confined to the Ohio River valley but are becoming widespread and successful experiences have been had elsewhere. A partial list of the places now thus equipped for carbon treatment of the water are South Pittsburgh, New Castle, Washington, Elizabeth, Chester, in Penna.; Hamburg, Olean, Waterford, in N. Y.; Rahway and Hackensack, N. J.; Morgantown, Huntington, Charleston in W. Va.; Springfield and East St. Louis, Ill.; Iowa City and Burlington, Iowa; Luke, Md.; Daytona Beach, Fla.; Newport News and Norfolk, Va.; Saginaw, Mich.; Minneapolis, Minn.; Louisville, Ky.; and Cincinnati, Defiance, Barberton, Upper Sandusky, Warren, Sandusky and Toledo in Ohio.

Points of Application and Costs.—Powdered activated carbon (Nuchar) may now be obtained in 75 lb. bags, 15 tons to the carload, at a cost of 5 cents per pound, f.o.b. Tyrone, Pa., or Piedmont, W. Va. No special equipment is needed to employ the powdered carbon at an existing water filtration plant, except a dry feed machine and a water eductor. Points of application vary; some apply to the raw water, or to mixing chambers with the chemicals, or to coagulation basins, or to influent water just prior to filtration. Experience seems to show that where plant layout permits, the ideal point to apply the powdered carbon is into the mixing chamber of a secondary coagulation basin; and where secondary mixing and settling basins do not exist, into the coagulated and settled water at the last pass of the basin before the water comes to the filter house. Important considerations for successful economical use of the powdered carbon are intimate mixture of the carbon suspension with the water treated; generous time of contact; a minimum of coagulant flow so as not to draw down the carbon at the point of application in the basin.

Rates of application of the activated carbon at plants that have operated successfully to remove algae and stagnation tastes have varied from 1 to 10 ppm. in the settled water, depending upon the intensity of the tastes to be removed. About 5 ppm. (0.3 gr. per gal., or 42 lb. per mil. gal., cost $2.10 per mil. gal.) appears to be sufficient to remove severe algal tastes or stagnation effects of considerable intensity.

Recent Experience at Sandusky, Ohio.—The experience of the Sandusky, Ohio, water softening plant is of interest. Originally this plant was an ordinary alum coagulation rapid sand filtration plant of the older type without mixing chambers, treating polluted water from Sandusky Bay on Lake Erie. Recently the plant has been rebuilt under the direction of Messrs. W. G. Clark and C. P. Hoover. The plant now is equipped for softening having two mechanically operated paddle mixing chambers and two Dorr clarifiers arranged for series operation ahead of one of the old coagulation basins. The layout makes possible the returning of sludge from the second clarifier to the first mixing chamber. About the time the new softening devices were put into service early this summer (1931) algae tastes and odors appeared in the water. People blamed the new process of softening for the bad tasting water. All efforts to overcome those tastes failed until activated carbon (Nuchar) was applied. Success immediately attended these efforts. The carbon was applied to the secondary mixing chamber following recarbonation with carbon dioxide; and since sludge is returned from the secondary clarifier to the first mixing chamber where the chemicals are added, the carbon in the secondary sludge is used over again. This reuse of the carbon before its discharge with the sludge has materially increased the efficacy of the process and reduced the cost of treatment. So severe were the criticisms against the new works that the chemist is now unwilling to discontinue the carbon treatment even though the condition creating the tastes probably ceases to exist at present.

Conclusions.—Summarizing the experiences with the use of activated carbon in the powdered form it appears that a very valuable and economical adjunct to water purification practice is now available for successfully removing practically all varieties of disagreeable tastes and odors that occur intermittently in water supplies. A consideration of the grief occasioned to water works officials when such tastes and odors have occurred in the past will lead most of us to believe that the added cost over relatively short intervals of time for the addition of activated carbon in powdered form, [$1.00 to $2.00 per mil. gal.] is well worth the money spent. And if the consumer were consulted the fractional extra cost for the treatment would be demanded once the results were evident. From a public health viewpoint the writer is firmly of the opinion that several times the cost shown would be warranted to prevent the public from losing confidence in the public water supply as a result of unpalatable drinking water. Confidence of the public in a safe and palatable drinking water must wherever possible be preserved.

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SEWER SYSTEM FINANCED BY SERVICE CHARGES.—Chewelah, Wash., a place of 1,315 population, is one of the first towns in the state of Washington to take advantage of the new state laws financing sewerage construction by service charges. The town recently voted $30,000 of bonds for the construction of the main lines. In addition it will be necessary to issue about $15,000 in public utility bonds for the construction of the laterals. It is estimated that the bonds should be retired easily in 20 years, from a service charge of $1.50 per month from the 250 users of the system.

OHIO CONFERENCE ON WATER PURIFICATION

THE 11th Annual Ohio Conference on Water Purification was held this year at Lorain, O., which was among the first cities in America to install rapid sand filtration and was the first filtration plant to be sold on a basis of guarantee to remove a specified per cent of the bacteria.

In a most interesting manner Thomas H. Tristram, Superintendent of Filtration, recounted his "Twenty-five years of Water Purification at Lorain, O."

The first day of the conference, with Frank Sheehan, Superintendent, Water Works, Portsmouth, presiding, was devoted to technical papers followed by an inspection of the Lorain plant and the evening banquet. The following day was devoted to an inspection trip to the filtration plants of Elyria and Avon Lake and the Sandusky softening plant.

The registrations were something over 110. Officers elected for 1932 are Chairman, W. I. Van Arnum, Youngstown; Vice Chairman, Thomas Tristram, Lorain; Secretary-Treasurer, J. M. Montgomery, Piqua, O.; Editor, T. R. Lathrop, Columbus.

Technical Papers and Discussions

"Reforestation of Reservoir Water Sheds"—A. D. Claggette, Superintendent, Water Works, Barberton, O.

Barberton spends $10,000 per year keeping its watersheds clean and in preventing pollution from reaching the reservoirs.

Reforestation of the watersheds was begun on a definite plan in 1928 when 50,000 trees were planted. The next year 17,000 were planted and in 1930 that number was increased to 34,000. There are now 85,000 in the nursery. Usually 1200 trees are planted to the acre.

Mr. Claggett believed the species of tree used for planting to be an important item and thought for Ohio conditions the red pine to be the most satisfactory from all angles, including the timber value. White and Austrian or Scotch pines and the Norway and White spruces were also satisfactory and the Norway spruce had been used along with Red pines at Barberton. The pines had been planted on 6 ft. centers which will later cover the soil with needles and prevent underbrush-growth. After 35 years (at 30 ft. height) every second tree might be cut out for timber. The trees planted in 1928 had already reached 4 to 5 ft. height and after 15 years of the program the cost for reforestation should be reduced to $2500 per year. Barberton expected to plant 800 acres more.

One scheme of financing reforestation is that of planting Norway spruce later to be harvested after 5 years and sold for Christmas trees at a wholesale price of 30 ct. each. The spruce stock costs less than other varieties and it is estimated that 2500 to 3000 Christmas trees per acre might be harvested every ten years.

Seedlings 2 years old purchased from the State Department of Forestry cost $2.50 to $4.00 per 1,000 and transplants 4 years old cost $8.00 to $8.50 per 1,000.

Losses of trees planted had been slightly above 1 per cent.

C. P. Hoover stated that Columbus had planted 40,000 evergreens on the watershed but losses in the dry year 1930 had been 25 per cent. Last year many black walnuts had been planted and were thriving so far. The harvested nuts should have a value.

F. D. Paul, Superintendent, Water Works, Akron, reported that 350,000 trees had been planted by them at a cost of $15,000 during the past three years and there were 500,000 small trees now in their nursery.

F. H. Waring reported that Youngstown expects to adopt the Barberton system shortly.

"Experiences in the Use of Activated Carbon"—C. E. Trowbridge, American Water Works & Electric Co., New York City.

Mr. Trowbridge recounted his company's experiences in the use of powdered activated carbon during the trying times of the 1930 drought when taste troubles were at their worst. Ten plants had used it with success and in some cases it had been applied to the raw water and in others to the influent to the filters. Between 5 and 20 lb. per million gallons applied at the latter point had not reduced filter runs and experience

M. Clark, Marble Cliff Lime Co., Columbus, O.

"Tommy" Tristram, Superintendent Water Works, Lorain, Ohio

E. A. Kimberly, Consulting Engineer, Columbus, O.

R. R. Weber, Mathieson Alkali Works, Cincinnati — *T R. Lathrop, Secretary, Ohio Conference on Water Purification* — *N. J. Humason, Superintendent Filtration, Elyria, O.*

had indicated the desirability of feeding the carbon through an injector in order to thoroughly wet every particle prior to application.

At their plant a test which promptly discloses the effectiveness of odor or taste removal and is also used to evaluate the quality of the raw-water consisted of a distillation procedure and observations were made on the "first runs" during the distillation. The test had enabled them to predict taste and odor troubles in advance and was used as a guide in the treatment applied. He believed the carbon treatment to be the most satisfactory means of positive relief.

Mr. Taylor reported on the satisfactory results from activated carbon applications at Defiance when lime-soda softening and prechlorination (0.75 to 1.5 ppm. dosage) had been employed. Powdered carbon applied at rates of 5 to 8 lb. per million gallons to the settled water just ahead of the carbonation chambers had resulted in the production of tasteless and odorless water for the first time in five years.

The carbon ("Nuchar") had been satisfactorily fed through a Wallace and Tiernan dry feeder with injector. Filter runs had not been retarded.

Mr. O'Connor, Superintendent of the Warren filtration plant had not been successful in taste removal with carbon up to 3.6 parts per million applied to the filter influent during a short run.

Mr. Van Arnum, Superintendent of the Youngstown softening plant had not found results satisfactory when applying carbon to the raw water during a 52 day period at a rate of 6 lb. to the million gallons. When added to the filter influent at rates of 15 or 16 lb. per million gallons tastes had been eliminated from the filtered water.

Mr. Schoepfle, Superintendent of Filtration at Sandusky had experienced severe taste troubles in the softened water assumedly due to algae and decomposition products from organic matter. Powdered carbon had solved the difficulties. He had struck on a method of using the carbon over and over again and had found its reuse in conjunction with return of softening sludge to the raw water to be superior to the first use. He believed the carbon in contact with the sludge had become more finely divided and therefore remained longer in suspension and contact with the water. Thus applied much of the carbon travelled to the filters also and two parts per million carbon dosage (Nuchar) had resulted in a 100 per cent effectiveness of taste removal. The cost had been $1.00 per million gallons which was amply justified and carbon use was being continued even now, but at about half the initial rate. The results seemed to justify the slight added expense even though the taste conditions had practically cleared up. Until the return of sludge and consequent carbon reuse was started the results with carbon were not more than 90 per cent effective.

Mr. Pelle, of Upper Sandusky, had experienced a marked increase in the brilliancy of the water following powdered carbon use ahead of the filter.

Mr. Rupp, Superintendent, Filtration at Topeka, Kan., had used 10 to 12 lb. of carbon per million gallons applied to the carbonation chambers. The results had been nothing to brag about but he expected to repeat the trial in a little different way.

Mr. Cameron, now with J. N. Chester, Engineers, and formerly Superintendent of the Fostoria softening plant reported that experiences at South Pittsburgh had indicated that 2 parts per million of carbon applied just ahead of the filters, produced results which had required considerably more when added to the raw water.

Mr. Gettrust, Superintendent of the Akron filtration plant had experienced severe taste troubles in the dead ends on the distribution system. The difficulty was traced to algae passing the filters between the walls and the sand when the beds had shrunk. He had overcome the difficulty by use of heavy prechlorination, increased wash rate and more frequent washings—say at loss of head of 3 to 4 ft. only. Prechlorination is being continued with beneficial results and longer filter runs are now possible.

"The New Findlay Softening Plant"—E. I. Roberts, Consulting Engineer, Toledo, O.

Mr. Roberts gave a rather complete description of the new 4 mgd. capacity softening works at Findlay, O., which employs the lime-soda process in conjunction with complete softening of about 50 per cent of the lime softened water by passage through gravity type filters filled with Zeolite instead of sand.

An ingenious arrangement of Simplex rate con-

trollers had been installed on the clear water wells to provide an automatic mixing of half and half of the lime-soda softened water (250 ppm. total hardness) and that of zero hardness from the Zeolite filters. The result was a uniform product leaving the plant with a hardness of approximately 100 parts per million.

Reduction of total hardness of 516 in the raw water at present to 100 had been accomplished to date at a cost for all chemicals including salt amounting to $26.00 per million gallons.

The plant cost $350,000, and had been paid for from an accumulated fund comprising profits from water works operation during the past several years.

"Larval Contamination of a Clear Water Reservoir"—Clarence Bahlman, Superintendent, Filtration, Cincinnati, O.

The breeding of the Chironomous fly in the mud deposits in the Cincinnati filtered water basins had caused untold trouble and passing from egg to adult fly the larvae commonly called blood-worms, had to some extent entered the distribution system.

To overcome the difficulty the basin was drained and cleaned of the bottom deposits which were alive with these red worms. The Chironomous fly resembles very closely a mosquito and is often taken for such by the layman. The cycle from egg to fly covers five days and apparently the covering of reservoirs is the only positive measure for prevention of Chironomous plagues.

Mr. Enslow, of New York, recounted his experiences with the same fly in the raw water at Gatun, Canal Zone, in which instance the larvae had actually choked down the runs of the filters and then had hatched out and gave no trouble from recurrence for a considerable period. The same fly had been the cause of an extremely bad nuisance this past summer on Back River near Baltimore. This tidal estuary had been literally covered with the sheaths of the hatched pupae and the flies were not held back by screens of ordinary mosquito wire.

It was evident that the Chironomous was no selecter of breeding grounds since this estuary received sewage effluent from the Baltimore works and was in reality a mixture of Chesapeake Bay water with oxidized sewage effluent. The sewage plant had been held to blame for the fly "plague" until it had been identified as the same fly which had also chosen the Gatun filters and Mr. Bahlman's filtered water reservoir as equally satisfactory breeding grounds.

"Softening Plant Sludge Disposal"—C. C. Whysall, Superintendent, Softening Plant, Marion, O.

The sludge from the Marion softening plant is lagooned and after 6 to 8 months the sludge will contain 20 per cent moisture in the top foot and 35 per cent at depths lower. Farmers haul this paste-like material away for use on land. One farmer had taken 80 loads of roughly 4500 lb. each. A manure spreader is used to distribute it. The bottom of the spreader is covered with straw and the upper 10 inches is filled with the sludge just as it comes from the lagoon. The spreader handles this sludge which contains 35 per cent moisture satisfactorily. Its acid neutralizing power amounts to perhaps 1.2 times that of agricultural lime ($CaCO_3$) because of its high content of hydrate of magnesia.

An attempt to get rid of sludge by discharge to the river during heavy stream flows had proven unsuccessful and sludge had been deposited on the stream bed within the first 800 ft. below the plant.

Mr. Fretter, of Medina, O., had tried the same idea of getting rid of sludge in the river and with the same disappointing result.

C. P. Hoover, of Columbus, called attention to the high value of sludge from the Miami, Fla., plant when used for filling low swampy areas. Sludge from 1 million gallons of softened water was sufficient to cover 1 acre to a depth of 6 in. After 3 to 4 months the sludge deposited had been covered with 6 in. of earth, which had thereafter been used for truck gardens very satisfactorily.

"Cleaning Solution Feed Lines"—C. C. Whysall, Marion, O.

Because of rapid clogging of the feed lines when lime and soda solutions had been run together through an injector it had been necessary to separate the two solutions and application through different pipe lines.

Because of high water consumption and clogging difficulties the solution injectors had been replaced by open impeller centrifugal pumps. It has also been shown that the more dilute lime emulsion employed had given less clogging troubles and a markedly higher softening efficiency. In place of using raw water to carry lime and soda the softened water has proven less scale forming and is now employed.

Replacing reinforced wire wound rubber hose lines with common fire hose had proven of practical value when necessary to clean out the lines. At every softening plant a complete set of boring tools for pipe line cleaning are a valuable adjunct. Soda lines may be cleaned with hot water. Steam is likewise valuable.

"Experiences with Brilliant Green Bile Media" was reported on by **Mrs. Rosemary Bole** of the laboratories of the State Health Department. The results from 1324 tests indicated that as far as the bile media recommended for the new Standard Methods of Water Analysis was concerned it had given results on a par with the ordinary lactose broth and there was little to choose between the two except that less laboratory work would be required due to the elimination of some gas production by other organisms than the fecal types. If any of the growth of the aerogenes-coli group is inhibited in the bile media, the aerogenes may be but not the coli. Brilliant Green Bile broth used in parallel with lactose broth will prove highly efficient and apparently would miss less than 1 per cent of the aerogenes-coli group. Solid media used in confirming might be dispensed with where these two broths are employed in parallel.

"Proof of the Effectiveness of the Ammonia-Chlorine Treatment at Cincinnati"—Clarence Bahlman, Superintendent, Filtration, Cincinnati, O.

Water from a newly covered roof on the filter plant had drained into the filters and created chlor-phenolic tastes in the final water. The use of ammonia at a rate of 1.3 lb. per million gallons, applied two minutes ahead of the chlorine which was applied at the rate of 1.75 lb. per million gallons, had prevented the taste from forming.

The trouble was found to be caused by the coal-tar product used on the new roof. This occurrence would seem positive proof that true chlor-phenolic tastes are preventable by using the ammonia-chlorine process. Ammoniation was started at the Cincinnati plant in July, 1931, and since then no taste troubles have been experienced. The real test however will come at Cincinnati between Nov. 1 and March 1, a period during which bad tastes have been experienced during 9 of the past 10 years.

OHIO CONFERENCE ON SEWAGE TREATMENT

THE fifth of the Ohio Conferences on Sewage Treatment—called annually by the State Department of Health—must be conceded to have produced the most interesting program and to have been the best attended of these meetings yet held.

Upwards of 120 registered for this conference, held at Akron, O., Oct. 13th and 14th, with more than 150 attending the annual dinner which was presided over by "Doc" Fred Ayer, Dean of the Engineering College, University of Akron, an able toastmaster.

By courtesy of the Goodyear-Zeppelin Corporation, several reels of motion pictures showing the construction and trial flights of the U.S.S. "Akron" were run to illustrate a talk made by an official of the company. The following day the conference had the opportunity of close range inspection of the new ship in her hangar.

After the conference was officially closed by M. W. Tatlock, Chairman, the members visited the sewage treatment plants at Akron and Elyria, O.

Group Picture of Those Attending the Ohio Conference on Sewage Treatment, Held Oct. 12-14 at Akron, O.

One bit of business transacted by the conference makes it practicable for the Ohio group to become affiliated with the National Federation of Sewage Works Associations through the creation of a subsidiary organization.

Officers elected by the Conference for 1931-1932 are the following: Chairman—George E. Flower, Cleveland, O.; Vice Chairman—Ralph C. Sweeney, Toledo, O.; Secretary-Treasurer—T. C. Schaetzle, Akron, O.; Editor—F. D. Stewart, Columbus, O.; Member at Large—A. H. Fretter, Medina, O.

Papers and Discussions

Among the outstanding papers presented was that by **B. F. Hatch** of the Engineering Division of the Ohio State Department of Health, which dealt with **"Trickling Filter Loadings"** and the various means of arriving at sewage filter loadings.

The comparison of loadings applied on the trickling filters at eight important Ohio plants were given for the purpose of comparing loadings and results secured from these filters. The evidence gathered by Mr. Hatch pointed to the fact that sewage filter loadings should be considered in terms of "pounds of oxygen requirement (5 day B.O.D. value) per unit volume of filter material involved." He believed that, after all, this measuring stick would evaluate loadings much more scientifically than the commonly used expressions of loadings in terms of "population per acre-foot" or "gallons per acre," or "gallons per acre-foot." The terms now employed may or may not have a definite relationship to actual quantities of putrescible materials applied to these oxidizing devices, which is the true criterion.

Tentatively, at least, the oxygen demand loading factor, not to be exceeded for any continuous period, would appear to be 250 lb. of 5-day oxygen demand per acre foot if a stable effluent is to be produced. This corresponds to an actual oxygen requirement loading of 5.83 lb. per 1000 cu. ft. of filtering material. It roughly corresponds to domestic sewage contributed by 2500 persons to each acre-foot of filter and the loading in terms of gallons per acre-foot be then what it may depending upon the per capita water consumption, infiltration, etc.

Mr. Hatch pointed out an interesting feature of trickling filter performance, viz.: their ability within rather wide limits to remove approximately 80 per cent of the applied loading in terms of oxygen demand. There is an upper limit of concentration of sewage and a lower limit of dilution which must be taken into consideration. In the case of very dilute sewages the rate of passage through the beds will prove an important factor because a certain period of contact with the surface of the media is required for oxidation of the applied organic matters. On the other hand, strong sewages have an inhibitory effect on filter performance. Creamery wastes, for example, cannot be successfully dealt with unless these are diluted to secure an approximate value of 400 parts of oxygen demand if one is to maintain oxidation efficiency through the filter beds.

In actual practice, the Fostoria plant with an applied filter loading of 8.19 lb. of oxygen requirement per 1000 cu. ft. of filter stone removed but 5.3 lb. per 1000 cu. ft. with a resulting efficiency of only 64 per cent and an effluent which was not stable. The data presented showed that the filters at Columbus, when taking everything into consideration, had done an unexpectedly good job of removing 10.3 lb. of oxygen requirement per 1000 cu. ft., leaving about 5.3 lb. Again the percentage removal of 5-day oxygen demand approximated that secured through the Fostoria filters when overloaded, whereas, with lesser loadings as applied to other filters, the removals reached 80 per cent or thereabouts.

Although Mr. Hatch did not feel prepared to make a definite specification naming a limit to filter loadings, he believes that the evidence shows that the limit is well under 8 lb. of oxygen demand per 1000 cu. ft. and

probably not much in excess of the tentatively chosen limit of 5.83 lb. per 1000 cu. ft.

Limited time prevented discussion of Mr. Hatch's paper from the floor and since it contains material of importance which should bring forth reader discussion this paper is printed in condensed form on another page in this issue. The Department of Health invites discussion of this topic and the 1932 conference will be presented with further evidence and arguments covering trickling filter loadings and results secured.

"Operating Difficulties at Akron's Sewage Works" was covered in a paper read by **T. C. Schaetzle,** Chemist in Charge of the Akron plant.

Several difficulties with the mechanical equipment had been eliminated. Trouble with rags getting caught in the detritus tank pumps and the blades on the Dorr mechanism had been eliminated through redesign of the Yeoman centrifugal pumps by the manufacturer and the raising of the scraper blades on the mechanism by the Dorr Co. to about 1 in. clearance above the concrete bottom of the detritus and grit removal tanks.

one screen out of service and cleaning it with a broom and water had proven more effective. The moisture content of the fine screenings has been rather high (91 per cent) but since incineration is not practiced no particular difficulty results. Efforts to produce drier screenings have not been fruitful.

Vapors coming down the sewer and later condensing on machinery in the detritus and grit handling room had proved troublesome prior to the erection of a partition to separate the sewer inlet chambers and bar-screen platform from the rest of the building.

Imhoff tanks had given considerable trouble due to fine sludge entering the flow compartment through the slots. It has been necessary to keep the sludge level 10 ft. below the slots to overcome that difficulty and to keep the flow chambers free of floating scum. Foaming had been overcome by applying water copiously to the gas vents.

No success had been had with the original scheme of disposing of humus sludge from the final tanks by introducing it into the digestion compartment of the

Continuation of Group Picture. Over 120 Registered for This, the 5th Annual Conference Called by the State Health Department

The Jeffrey grit conveying mechanism had been improved by removal of alternate scraper blades and equipping it with a slack adjuster to take out the play in the chain. Shear-gates on the Imhoff tanks had given trouble until equipped with lubricating grease cups on the stem bearings and stuffing boxes.

Freezing of piping in the syphon chambers had been overcome by installing bleeder lines on the system in order to drain it wherever the syphons were cut out of service in winter.

Gate valves on the ends of the trickling filter distribution lines had burst because of freezing although the valves were left open. Drain plugs were installed in the lower part of each valve to overcome this trouble. Contraction during the winter shutdown had caused some of the joints on the distribution lines to part as much as 2.5 in. requiring the placing of expansion sleeves in these lines. The half-spray side nozzles had been improved by attaching a collar of lead which extends up to the bead at the top of the spray cone and extending around the outside half of the nozzle.

Grit in the humus (secondary) tank sludge had cut out the packing in the humus pumps. A water fed sealring has since been installed in the stuffing boxes by the Yeoman Co. and has solved this difficulty. The bronze bushings on the impeller shafts had been replaced with stainless steel bushings which have not been cut out by the grit since the change which was made more than a year ago.

Clogging of the slots in the Dorr mechanical screens had at first been corrected by daily applications of kerosene oil. Lately the more practical scheme of taking

Imhoff tanks. Regardless of the several schemes tried including several experimental points of discharge of the humus tank sludge its introduction caused serious difficulties from scum rising upwards through the slots into the flow chambers. Disposal of the humus by building lagoons to hold it had been found to be the most practical solution of the problem. Occasionally it had been run onto the sludge beds also. The tremendous sludge accumulations in the Imhoff tanks had required construction of more drying beds, and the lagoons are used in addition.

Trickling filters had given trouble due to solids accumulations on and near the stone surface and pronounced ponding with loss of efficiency had resulted. The filters had been cut out of service during the past winter on this account with the approval of the State Department of Health. To correct the ponding, chlorinated lime and also "H. T. H." had been applied with successful results to some of the filters. Harrowing of the surface stone had given relief to others. The filters are at present operating efficiently and the approaching winter will determine the efficacy of the remedial measures being applied. A combination of infrequent chlorination followed by harrowing at intervals would appear to offer the most practical and economical solution to the ponding problem at Akron.

Sludge disposal had necessitated the construction of lagoons of 200,000 cu. yd. capacity and the installation of 8.5 acres of auxiliary sludge drying area adjacent to the plant.

"Sludge Digestion," by **R. A. Allton** of Columbus, O., suggests definite formulas which should prove ap-

plicable in determining sludge capacities required to handle given input of solids to a sewage works.

Digestion and consequent disappearance of solids as gas or liquid follows the mono-molecular law which is based on the fact that the rate of digestion is constant; i. e., if 10 per cent digests the first day then 10 per cent of the residual 90 per cent digests the second day and then 10 per cent of the residual 8 per cent the third day and so on.

Studies recommended by Mr. Allton should disclose considerable information in connection with the sludge digestion capacity requirements at sewage works to be constructed.

C. D. McGuire, Superintendent Sewage Works, Columbus, O. *A. B. Bacherms, Sewerage Engineer, Akron, O.* *B. R. Garudacher, Sanitary Engineer, Mysere, India*

F. W. Jones of Cleveland in discussing the paper by Mr. Allton said that he believed that formulas based on dry solids content of sludges could not be dependable for practical application in view of the tremendous variations in moisture content of sludges to be dealt with at most plants. For example, a sludge containing 95 per cent water will weigh 65 lb. per cubic foot whereas the same dry solids content would occupy 2 cu. ft. if the moisture content be increased by 2 per cent, viz.: to 97 per cent. Thus, an increase of moisture content by 2 per cent will necessitate twice the storage capacity to handle the same weight of dry solids to be dealt with. The moisture content of sludge is therefore of considerable consequence in actual operations and plant design.

C. D. McGuire spoke of the chemists' responsibility in supplying the designing engineer with the data required for design purposes.

E. Sherman Chase, Consulting Engineer of Boston, Mass., at this point brought up certain important items in sludge digestion tank operation and then described the results of the recent sludge gas explosions at the Woonsocket, R. I., sewage works and the probable causes.

J. W. Ellms of Cleveland recounted the difficulties met with in operation of Imhoff tanks in which non-digestible material accumulated and required special equipment for its removal from the digestion chambers. Tank design should contain provisions for ready removal of such accumulations from digestion tanks when occasion arises.

Mr. Schlentz of the Pacific Flush Tank Co. reported on observations which disclosed a constant relationship between the volatile solids content of solids added to a digestion tank and the residual volatile solids left in the digested sludge.

This observation brought forth the question from **George Gascoigne**—"What is well digested sludge?" to which one answer given seems fitting. "When our tanks are all full and sludge *has* to be taken out we consider it as digested sludge." At Marion, O., the sludge, according to **Floyd Broune,** is considered well-digested when the 75 per cent volatile solids content in the fresh solids added are reduced to between 50 and 52 per cent volatile in the digestion tank sludge. Such a sludge usually contains but 92 per cent water when drawn and has a nitrogen content of 2.5 to 3 per cent and dries readily on the beds. At Akron, sludge 3.5 months old contains 52 per cent volatile matter and drying quality is satisfactory. This is considered, according to **T. C. Schaetzle,** to be well digested sludge for Akron conditions.

J. R. Collier of Elyria has to deal with digestion of activated and primary tank sludges mixed. He believes it impractical to base opinions of degree of sludge digestion on the volatile matter content alone. At Elyria 46 to 48 per cent volatile solids in the sludge drawn is aimed at.

Mr. Allton thought that perhaps the practical answer to Mr. Gascoigne's question might be "A sludge that can be drawn without producing nuisance from odors and naturally it must possess good draining qualities."

"Operation Results at the Elyria, Ohio, Sewage Treatment Plant" by **J. R. Collier,** covered the following interesting items:

The Elyria plant is of the activated sludge type and now treats approximately 2,000,000 gal. of sewage per day with a normal aeration period of four hours being given the effluent from Imhoff tanks. Sludge from Imhoff tanks mixed with activated sludge is transferred to separate digestion tanks equipped with floating covers. The excess activated sludge is pumped into the crude sewage with satisfactory results.

Screenings from the bar screens amount to 2.22 cu. ft. per million gallons. Skimmings from Imhoff tanks (1.40 cu. ft. per mg.) are buried or covered with chlo-

rinated lime. Scum from under the gas domes on the Imhoff vents is transferred to the digestion tanks twice monthly.

The sewage flow received, being below the designed capacity, receives 1.5 cu. ft. of air per gallon at 7.5 lb. pressure. Because of the excess air available between 4000 and 5000 parts of dry solids per million (by weight) are carried in the aeration units. In the final clarifiers a sludge depth of 3 to 5 ft. is carried. The heavy return of sludge to the aeration units serves to prevent "upsets" caused by industrial wastes. The sludge carried in the final tanks is considered as storage sludge which is available for sudden demands.

The Imhoff tanks reduce the 5-day oxygen demand by 39 per cent and the total reduction through the plant averages 96 per cent.

The separate digestion tanks are maintained at 77° F. The sludge transferred weekly from the Imhoff tanks contain 97 per cent water and volatil solids of 55 to 65 per cent on the dry basis. The crude sewage solids run 72 per cent volatil matter in comparison. The digested sludge drawn to the sand beds carries 46 per cent volatil solids on the average and 94 to 95 per cent water. Supernatant liquor from the digestors is discharged to the sludge compartments of the Imhoff tanks weekly before sludge drawings. Sludge or scum from any part of the plant can be drawn onto the glass covered sand beds at will.

Sludge when dry (50 per cent water) is removed from the sand beds by the purchasers, who pay $5.00 per bed for it.

About 48 per cent of all gas produced is burned for heating the digestors and the remainder is wasted. Gas from the Imhoff tanks is consistently of better grade than that from the digestors. The former has 87 per cent methane content and 900 B.T.U. value whereas the digestor gas contains but 70 per cent methane and 744 B.T.U. value. Total gas production averages 0.5 cu. ft. per day per capita.

The operating cost has during 1931 been at the rate of $23,430 per year—equivalent to $23.45 per million gallons.

TOPICS OF ROUND TABLE DISCUSSION

"Grit Chambers and Their Operations" was covered by **A. E. Hess,** Superintendent, Alliance Sewage Treatment Works.

"Trickling Filter Operation and Maintenance"—C. E. Hommon, Superintendent, Sewage Treatment Works, Canton, O.

Mr. Hommon believed that the filter fly could best be controlled by bed flooding at intervals of 7 to 10 days during the hottest weather and less frequently during cooler weather. He had found the removal of the heavy film from the stones to be beneficial both in fly control and in increased filter efficiency which was apparently due to the thinner film on the stone being more effective.

The flooding and resting of filters at Canton had resulted in cleaner beds without spiders or worms and that he had found that the cleaner beds could stand heavier loadings of sewage applied than previously was possible. He considered the filters at Canton, which are filled with slag as the media, as entirely satisfactory with the methods of operation employed, i. e., flooding by rotation and thereafter allowing a rest period before placing the unit in service again.

In reply to a question from **E. S. Chase** of Boston, Mr. Hommon reported that the use of chlorine experimentally for odor control had resulted in filter unloading when first applied three years ago. Chlorination was now used regularly for odor control at rates varying between 6 parts during maximum flow and perhaps 20 parts during minimum flow. Ten days of the high rate applied at night had not made much difference because the filters were already clean before starting the new treatment.

C. D. McGuire, Superintendent, Columbus Sewage Works commented on the ordinary chlorination as compared to the use of lime and chlorine in combination for odor control and filter ponding. The Columbus experience had shown that the almost continuous application of sewage to the overloaded filters at the rate of 4 mg. per acre per day seemed to prevent filter fly breeding to a considerable extent.

Mr. Hommon in reply to a question stated that he

C. C. Hommon, Superintendent Sewage Works, Canton, O.

B. F. Hatch, Assistant Engineer, Ohio Department of Health, Columbus, O.

Geo. E. Flower, Chairman, Ohio Conference on Sewage Treatment, Cleveland, O.

had found that when the breeding was at its worst the filter flies reached a dairy at least ½ mile from the treatment plant.

F. W. Jones of Cleveland expressed his belief that resting of filters had helped control fly breeding at the Fitchburg, Mass., plant and that heavy loading of filters would probably result in reduced breeding. He had found that tricking filters first removed solids from the sewage by contact with the stone and then proceeded to reduce these solids to liquids and gases. Between 15 and 25 per cent of the total solids were thus disposed of by filters and the remainder accumulates to be disgorged as humus matter later.

"Gas Production" was covered by **Mr. Yaxley,** Chemist, Dayton, O., Sewage Treatment Works. Experiences at Dayton with gas production indicated that there was a definite ratio between temperature increases, the rate of solids digestion and gas production but that temperature increase had not produced any more total gas than otherwise had occurred within extended periods. The production had been 67,000 cu. ft. daily in Jan. at 13.3°C. sludge temperature whereas at 23.5°C. the maximum of 85,000 cu. ft. per day had been recorded at Dayton.

Mr. Barcroft, City Engineer, Salem, O., had found that variation in ratio of crude sludge to activated sludge when mixed in the digestion tanks would result in a variation in rates of gas production.

Mr. Schlentz, Pacific Flush Tank Co., New York, had found that more than the 1000 cubic centimeters of gas per gram of volatile solids, usually found in laboratory experiments, was practically always produced in plant practice.

E. S. Chase of Boston at this juncture showed films of important sewage treatment works in England which were taken during his recent visit abroad. The Birmingham works he had found particularly interesting in that aeration by the Simplex equipment and diffused air methods were being compared.

"Methods of Suspended Solids Determinations"—Mr. Monroe of the Akron Sewage Works Laboratories recommended the Gooch crucible method as the best for Akron sewage.

At Cleveland "filter-cell" added on top of the asbestos matte in the crucibles had aided the filtration process materially.

"What Constitutes Odors About a Sewage Plant"—L. H. Enslow of New York explained that this topic had been given him as a "pinch-hitter" and therefore his remarks might be lacking somewhat.

Odors about a sewage plant were noticed in two distinct ways by visitors. The first could be smelled through the nose but equally as repugnant to the layman visitor were those which he would "smell" through his eyes.

The several sources of odor nuisance from sewers and sewage treatment plants were discussed and the conclusion reached was that fresh sewage causes no odor nuisance and therefore sewages should be kept as fresh as practicable during their travels to and through the treatment works. Further than this the manner of operation, the cleanliness of the plant and the appearances of the surroundings would usually determine the reputation of any plant in so far as actual as well as "visible" odor nuisances were concerned.

It was now generally conceded that stale or septic sewage created odors primarily because of its content of hydrogen sulphide and therefore it should be destroyed if already formed but better yet its production should be held in check by treatment of the sewage to suppress bacterial activity and thus hold in check further septic action.

J. W. Ellms of Cleveland related his experiences with odors from industrial plants and the sewage treatment plants at Cleveland, the operation of which are under his supervision.

E. S. Chase raised the fine question of "When do odors become a nuisance and particularly when do odors become a health problem?" Needless to say, this one was not very satisfactorily answered.

F. D. Stewart of the Ohio Department of Health referred to the chlorination process successfully employed at the Dayton Sewage Plant for odor control and requested the Chairman to relate some of the results secured.

"Odor Control by the Lime-Chlorine Process at Dayton, Ohio"—M. W. Tatlock, Superintendent Sewage Treatment Works, Dayton, O.

At Dayton the continuous preparation of an alkaline hypochlorite by merging together lime emulsion and chlorine water in the so called "lime-chlorine process" had been in use at their plant since July 18th. The solution so produced was applied to the crude sewage as it reached the plant and had not only controlled odors but had produced several other distinct benefits. Among these were found a greater efficiency of plant performance and an appreciable reduction in the oxygen demand of the tank effluent. Labor reduction in tank operation had been appreciable and scum rising in gas vents and through the slots into the upper chamber of the Imhoff tanks had been reduced to a minimum.

The oxygen demand reduction by the tanks had been increased to a total of 67 per cent during the first three weeks of chlorination but at the present time the introduction of a very strong sewage had reduced that figure to 55 per cent.

Sludge and scum drawn had been reduced in volume which in effect had been equivalent to a 16.5 per cent increase in the capacity of the coverage sludge beds.

The average chlorine employed had been 74 lb. per million gallons of sewage treated and the hydrated lime dosage maintained was 1.3 times the chlorine dosage. The entire cost had been roughly $2.22 per million gallons treated.

George B. Gascoigne of Cleveland brought out the fact that the golf course being located so near to the Dayton sewage works had necessitated the steps taken toward odor abatement and that he should not think property adjacent to sewage plants suitable locations for golf courses, country clubs or residences. He had therefore pursued the policy of recommending the isolation of sewage plants as the best practice.

Mr. McGuire of Columbus remarked that sewage plants were frequently held to blame for odors produced by some neighboring industrial plant, a garbage dump, a reduction works, or rendering plant. That, in fact, was the situation at Columbus and he would like to know what could be done about it.

"Sludge Dewatering Experiments" by **R. A. Alton,** Sewerage Engineer, Columbus, O., reported that some promising results were being secured experimentally at Columbus from vacuum type filters used for dewatering digested sludge. Ferric Chloride had proven the most efficient coagulant and two filters—the Oliver and the Genter—had been tried. If the experiments were a success sludge handling and drying would become much simpler than as present practiced and a material area reduction for plant-site would naturally result.

HAVE YOU A CHLORINE RESIDUAL?

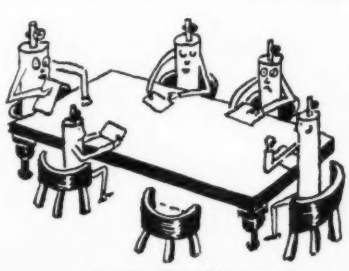
By **MORRIS M. COHN**
Sanitary Engineer, Department of Public Works
Schenectady, N. Y.

THERE is but one way to do anything and that is to wade right into the thick of it. It applies equally as well to everything in life. You can't write a tested recipe for a cake unless you have had your hands in sticky dough. The adventure tales you write from the secure refuge of your armchair will be a bit off-color. The actress who sheds glycerine tears over a lost love brings real tears to your eyes, only if she has had her share of divorces in real life.

Take operating a sewage-works, for example. How can you talk with conviction about the persistent odor of sludge, unless you have tried to rub sludge off the soles of your shoes? What do psychoda troubles mean to you, if you have never gotten the flies into your eyes or they have never made you feel itchy? More to the point, how can you have that artful chlorine control intuition, that vivid imagination needed by all "microbe hunters," unless you yourself have breathed deeply of the clinging, breath-taking gas?
have that artful chlorine control intuition, that vivid imagination needed by all "microbe hunters," unless you yourself have breathed deeply of the clinging, breath-taking gas?

When one of my colleagues starts to tell me what chlorine has done to his sewage or his effluent, in a heartless, matter-of-fact tone, I cast upon him a cold and withering eye. When I discuss chlorine massacre-methods, if you please, I speak with the warmth of feeling, the deep understanding of the action of chlorine, of one who has had a chlorine residual. This ability has not come to me cheaply. Hardly. I have been super-chlorinated to my most vital organs on many occasions, but my first encounter with the potency of chlorine still stands out as the experience which gave me that mellowness of feeling to which I have referred.

It was on a Saturday afternoon, as I recall it, when it all happened. Other self-respecting municipal officials were out disporting themselves on the golf links, but, I, in the company of the enthusiastic research engineer of The Chlorine Institute and a representative of a company which sells control apparatus, was sweltering under a hot summer sun, preparing for some chlorine experiments which were to prove something or other to a doubting profession. The plant was pervaded with the sort of calm which precedes a storm. The usual hustle-bustle of the working day was absent on the half-holiday. A skeleton maintenance crew was aiding us in our efforts to pull heavy chlorine cylinders up an inclined chute and into a chlorinator shelter perched high up over the top of one of our dosing tanks. This was before the day when chlorine cylinders went into a merger and formed ton containers which now stand like sturdy corporations of smaller, shakier firms. As a result, as I said before, we were getting cylinders up into the shed and backing them up in formation before a chlorinator manifold.



Another Big Merger

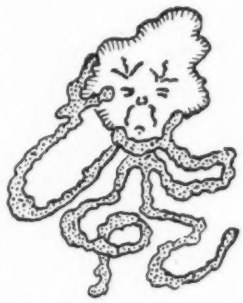
Here the tale of woe begins. That cylinder of chlorine which developed the leaking valve changed the complexion of the day which had started so pleasantly. It hissed menacingly as it started up the slope and a pungent vapor curled out from the slots of the protective cap. The lawn began to take on an autumnal hue as the tender shoots curled up and died. My ire rose as the devastation became more pronounced. My collaborators, those experts in chlorine, worked leisurely to shut off the offending valve. With heads turned aside from the blowing tank and with bated breath, they stepped up, twirled quickly and then retired to zones of less hazy atmosphere. Still the chlorine hissed, still the grass continued to bleach. Something had to be done. I, the novice in the ways of chlorine, galloped to the rescue. Fortified with a long breath of fresh air, I attacked the tank valve. All would have been well if my technic had been as unhurried as my companions. It was not. I stayed a bit too long. The blood pounded in my ears, my lungs ached for deflation. Nature revolted and I took one gasp.

Have you ever taken a long draw on pure, undiluted chlorine? I can guarantee the purity of the gas I inhaled. Suddenly, my nose and throat felt seared, strangely dry. My lungs throbbed, my eyes smarted and I entered a semi-daze in which my mental faculties were unusually alert. Everything I ever knew about chlorine flashed through my mind. As I reeled away to safer sections, I visioned the poor hacking devils who were victims of gas warfare. The cauterized lawn persisted in passing in panorama before my eyes and I could imagine every lung cell shrivelling and my blood turning from a rich red to an indeterminate watery hue. My chest felt as if it were in a vise. Each inhalation was like a sword stab. My breath came in labored pants. At regular intervals I set to coughing a sort of rasping hack that tore the lining of my stomach. I have never been a drinking man; to me, the literature reaching my desk from anti-prohibition and anti-saloon factions had about as much interest as would a monograph on the life habits of the extinct dodo. Howsoever, alcohol was prescribed for imbibing and inhalation by my co-workers. Did I say that those two worthy gentlemen showed a surprisingly slight worry about my condition?

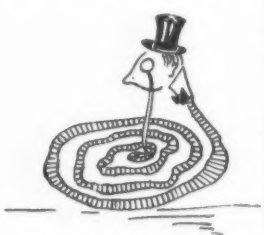
Even with the spirit of the grain, I was long recovering. I looked at my watch and at my ring and their state of tarnish lent added doubts about the condition of my inner linings. I spoke with the hushed, husky voice of a fan who had just rooted his home team to a baseball victory. I tasted chlorine in my nose, in my mouth. My breath must have had a residual chlorine that would have turned orthotolidin a blood red. There was no doubt but that my chlorine demand had been satisfied and that disinfection was complete. The dinner that awaited me at home was wasted as far as I was concerned. The steak, the potatoes and the dessert all had a chlorinous taste. My poor appetite I excused on the grounds of having a slight cold and my husky voice seconded the motion nobly. It was some time after this before I could approach a chlo-

rinator without shying. I visited my installation well fortified with a gas mask and a bottle of ammonia. The instruction book advised the testing of all joints at regular intervals; my tests were almost continuous. A puff of white fume following a dash of ammonia brought forth intensive activity with a wrench. It was a wily auxiliary valve union that got by me those days. I've had my shots of chlorine since then and have even dragged a tank of gas into my office and exposed myself and a few trusting friends to light doses to cure colds. I even sniff at a connection occasionally to check a leak. I have even learned to like chlorine for what it can do, even as I distrust it for what it almost did to me.

There is something to the theory that suffering lends a softness to the heart and a look of understanding to the eye. I have both of these attributes when I turn a chlorinator adjustment valve and watch the rate gauge come to rest at the desired dosage. I have applied chlorine to sewage, sterilized water supplies and swimming pool waters and piloted a chlorine boat around an outdoor natural bathing area. When the chlorine enters the water or the sewage, I can with full sympathy understand just how every last bacterium must feel as it breathes deeply of the gas and it sets to hacking and gasping as I did. There are any number of theories about just how chlorine destroys bacteria. After my experience that Saturday afternoon, I know that they just choke to death. I know that a water with a suitable residual chlorine simply has no spots of unchlorinated liquid to which the germs can squirm or whirl to catch their second wind. I know that algae curls up and dies like my grass did and that poor amoeba can no more wave their silly cilia than I could move my heavy arms when my chest cavity was full of chlorine. I can look at a colony on an agar plate of chlorinated water and feel a real companionship for the mother germ that formed the thriving settlement. She too, like I, took a gassing and survived.



"A bc" Coli Just Plain Chokes to Death



And "Algy" Just Curled Up and Died

Some day I will gather my grandchildren around me and tell them of the shot of chlorine that gave me the quality of mercy. Until then, I must satisfy myself telling my contemporaries how to acquire the experience that makes a good cook a better one, a chlorine user a chlorination expert. You will do your job well only after you have had a good husky chlorine residual.

CITY TO CARE FOR DELINQUENT WATER BILLS.—Through legislative action of the city council of Youngstown, O., the city health department today will have $5,000, transferred from the general fund, to pay for delinquent water bills in cases where sickness and extreme poverty demand that water be provided at the city's expense. The fund will be distributed only after the Allied Council has investigated and made recommendations to the health commissioner. It is estimated there are between 50 and 75 families without water who are in real need of this emergency service.

Rutgers University Announces First Annual Water Works Short School

Rutgers University, New Brunswick, N. J., announces a short course for filter plant operators and water works superintendents to be held at the university Dec. 7 to 19, 1931, under the direction of the College of Engineering in cooperation with the South Jersey Association of Water Superintendents and the New Jersey State Board of Health.

The course of study has been planned to provide instruction in the fundamental principles of water works management and maintenance and filter plant operation. The quality of water, development of the sources of public water supplies, design and operation of distribution systems and filtration plants will be covered by lectures and recitations. A laboratory course will be given covering the details of filter plant operation and in which the student will make actual tests and analyses.

The two weeks period of instruction offers an opportunity to those wishing to become operators and water works superintendents, to qualify themselves to meet the requirements of the New Jersey State Department of Health. It is also an opportunity whereby water works officials and employees may increase their knowledge of public water supply and of water treatment and to better qualify themselves to solve their individual problems.

Any person may attend the water works school. There are no educational requirements for admission. Certificates of attendance may be secured by those who desire them.

Instruction in the course will be given by members of the university faculty. Professor H. N. Lendall will have general supervision of the school and will conduct the recitations and lectures. Dr. Willem Rudolfs, assisted by his staff, will have charge of the laboratory work.

A description of the course follows:

Lectures and Recitations: Sources of water supply; surface and underground waters; wells; reservoirs; pipe lines and distributing systems; pumps and pumping stations; quality of water; water treatment; treatment plants; construction and maintenance of water supply systems.

Laboratory: Sampling methods; chemical examination of water; bacteriological examination of water; experiments (a) regulation of dosage of coagulant, (b) comparison of two well waters, (c) comparison of two surface waters, (d) efficiency of purification plant.

Two days will be devoted to visiting water plants within driving distance of New Brunswick. The trips are considered an essential part of the course.

Classes will begin at 10:30 o'clock Monday morning, Dec. 7, 1931. Class sessions will be scheduled daily from 9 to 12 in the morning and 1:30 to 4:30 in the afternoon and ending at noon on Saturday. The course will end Friday afternoon, December 18th. A schedule of classes will be supplied at the time of registration.

Definite periods will be assigned for informal "Round Table" discussion of various problems in water works operation and management. The discussions will be led by men of experience and authority in the water works field.

LABOR SAVING METHOD OF MAKING SERVICE RENEWALS

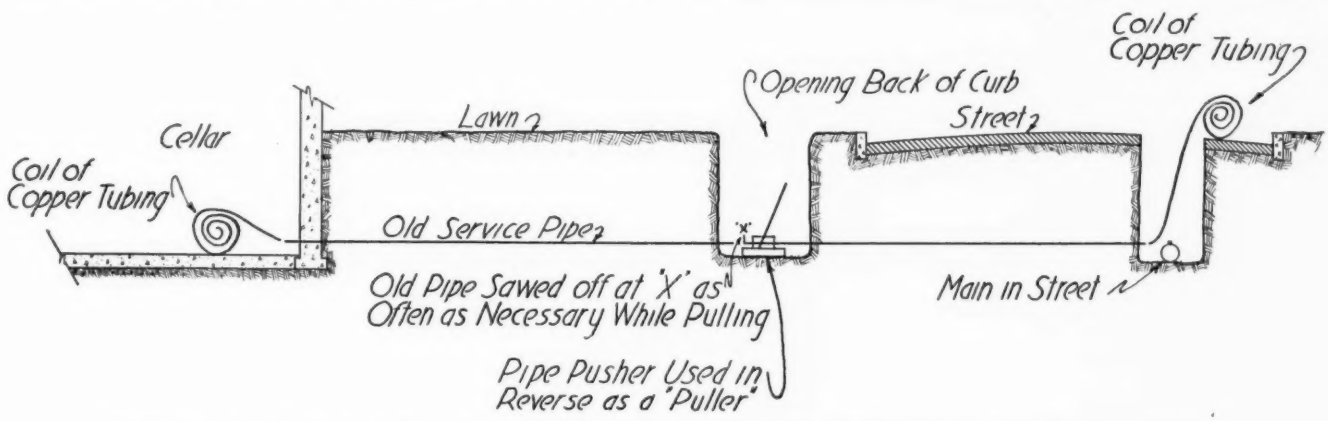
By ALFRED S. MALCOMSON
President,
Upstate Water Co., Inc.,
New York

NEARLY two years ago the use of copper tubing for new services was adopted as standard practice at all our plants, and quickly following that decision its use was extended to all service renewals as well. Few if any new or renewed services have since been laid of any other material, and it would now require very unusual circumstances to cause us to depart from the adopted standard.

Permanence was one of the strong points influencing the selection of copper as standard. Another was the belief that copper, being more flexible than brass, would be less apt to develop leakage as a result of earth settlement. Its ability to yield without fracture in the event of freezing was also a point in its favor. The use of lead was not seriously considered because such history as was available indicating its behavior at our plants in the past, led to the conclusion that although it usually retained its delivery capacity, its life was not materially greater than galvanized iron. Lead, under our service conditions, seems to honeycomb and fail after a service life averaging perhaps 35 years. Incidentally, a substantial portion of our services are galvanized iron which have been in use upwards of 30 years, and in numerous cases they are more than 40 years old. The capacity at that age is, as might be expected, very greatly reduced, but they nevertheless continue to give service without failure.

There were a number of other points in favor of copper which weighed even more heavily with us, and continue to do so increasingly. These are the ease with which the joints are made, their flexibility, the smaller number of them; the ability to pass easily around obstacles in the trench; and the small and compact space in which a 60 ft. length of coiled tubing may be transported. The very great benefit of the flexibility of the tubing in the case of renewals in particular was not at first appreciated, but it has since been realized and full advantage is now taken of it in the manner presently to be described.

For copper service work the only tools needed are a hacksaw with which to cut the tubing to the desired length, a hammer and flanging tool with which to form the joint, and two wrenches for tightening up the fittings. A little oil on the flanging tool, on the face of the joint, and on the threads of the fittings is helpful but not absolutely necessary. In nearly every instance there is some leeway in the length, as the tubing is seldom exactly straight. This avoids loss of time in case of an error of judgment in cutting.


Coil of Copper Tubing
Opening Back of Curb
Lawn
Street
Cellar
Coil of Copper Tubing
Old Service Pipe
Old Pipe Sawed off at 'X' as Often as Necessary While Pulling
Main in Street
Pipe Pusher Used in Reverse as a "Puller"

Sketch Showing Method of Renewing Old Service With Copper Pipe Without Trenching Across a Highway

Each joint is a union in that it may be connected independently of any other, which is also a time saver. And although the threaded portions of a coupling joint or of the adapter used for passing from copper to iron pipe, must be pretty closely aligned, there is usually enough play in the tubing to permit of securing such alignment readily. As the copper tubing comes in 60 ft. lengths the number of joints is reduced and in many instances no joint at all is needed between the curb box and the shut-off in the cellar. And in any soil which is at all "bony," the ability to readily pass a stubborn boulder by merely bending the tubing around it is a substantial economy both of time and temper.

Soon after commencing the use of copper tubing we undertook the renewal of a service which lay beneath a paved state highway that was subject to rather heavy traffic, and decided to try drawing out the old pipe with the copper tubing attached to it, thereby effecting the renewal without digging across the highway. A "Little Giant" pipe pusher was set at the curb (in reverse) and the old service was disconnected from the main. After removing the lead gooseneck a copper tubing was attached to it by a standard adapter and we found it readily followed through behind the old pipe, that we were pulling

through. The old pipe was sawed off as frequently as its length at the "puller" became bothersome. After drawing it clear through it was the work of but a few moments to form a gooseneck at the main and make the connections at each end.

Since then we have made many such renewals, both from the curb to the main and from the curb to the cellar, the pipe being drawn both ways to the curb cock as shown in the sketch. Where this can be done it enables us to renew the consumer's portion of the service at no more cost to him than he would incur in replacing with galvanized pipe and in addition he secures a new service which should last indefinitely without suffering loss of capacity. Also, he avoids having to dig up his front lawn, which is often a consideration of consequence. We have found that this method advertises itself well and that it has resulted in a number of consumers renewing their services sooner than they otherwise would, with a resulting satisfaction in the improvement of service the inadequacy of which had not been fully realized.

Pulling in of copper tubing has been successfully accomplished in most of the cases where we have attempted it even to drawing in ¾ in. tubing behind old ½ in. pipe. We have occasionally met difficulty or complete failure due to the old pipe parting, and have learned that it can only be pulled successfully if it be substantially straight. Lengths up to 100 ft. have been pulled but our experience leads us to believe that is about the maximum which should be undertaken unless the soil is especially favorable. There are many little kinks to be learned about the use of copper pipe and about pulling it in, but they are quickly acquired after a little experience. The sketch illustrates the way we do the job.

LETTERS TO EDITOR

Principles of Sludge Gas Collection

To the Editor:

In view of the tragic and costly explosion of digestion tanks at Woonsocket, R. I., on Oct. 2nd and reported in your October issue (the second such occurrence in similar tanks in about a year) a word about the design and handling of sludge digestion tanks would seem to be in order.

Such accidents are avoidable when the principles of sludge gas production are understood.

Mixtures of gas and air are inflammable when the gas constitutes between 5 per cent and nearly 50 per cent of the mixture or in other words, in any mixture that is respirable. Therefore, when we "ventilate" a sludge tank in order to prevent asphyxiation, we automatically produce explosive mixtures unless the ventilation is carried to such an extent that the gas is actually all removed.

Further, it is necessary to provide continuous, forced ventilation, if there is any sludge in the tank, as sludge generates gas continuously. As long as there is any sludge in the tank, what may be a harmless mixture one moment may become dangerous the next.

This is particularly true since sewage gas diffuses sluggishly and the mixture may vary widely in different parts of the tank.

For the above reasons tests of the gas in a tank are of little use in predicting safety. It is a simple matter to test for carbon dioxide, and we may assume that the methane content will be from 3 to 5 times the CO_2 content, therefore even one per cent of CO_2 would indicate danger, but its absence would not indicate safety.

In a recent case in New York State when it became necessary to send men into a digestion tank to make changes in a revolving sludge stirring mechanism, those in charge felt perfectly safe after they had filled the tank with sewage to displace the gas. They were, in fact, safe only in case the tank had been filled to overflowing with the sewage, and in case there was no sludge in the tank after the sewage used to displace the gas had been withdrawn.

In the Woonsocket case we are told that the tank had been partially emptied and that the covers had been removed for ventilation, before sending men in to repair the stirring mechanism. The removal of the covers simply provided ideal conditions for producing an explosive mixture.

It is not necessary to seek the source of the spark that starts combustion. There is abundant proof that combustion has started in a number of cases and our safety lies in avoiding explosive mixtures.

In Southern New Jersey, about a year ago, a tank with concrete cover above the sludge line blew up, causing havoc with the adjacent glass sludge bed covers but fortunately with no loss of life. This explosion was blamed, I believe, on the curiosity of a couple of visitors to the plant after hours.

The fundamental fault, however, lay in providing space for gas between the sludge surface and the concrete cover. Such conditions should not be tolerated. It is understood, also, that in this case there was an overflow or vent pipe leading from the upper part of the sludge tank to the inside of the glass enclosure. Such arrangements would be exceedingly dangerous as offering opportunity for air-gas mixtures and also for ignition of the mixture within the glass enclosure where one would little suspect danger.

In repairing leaks in gas holders, the experienced gas man does not attempt to ventilate the tank to remove the gas. On the other hand, he raises the pressure within the tank, makes sure that *only air free gas* is pumped into the holder, and then repairs the leak by welding on the outside. Applying this principle, we should attempt to collect sludge gas only under positive pressure.

Again applying the lessons brought out in this memo, whenever possible we should avoid sending men into any tank containing any sludge. When it is imperative to send men into tanks containing even a small quantity of sludge, we should provide powerful, and *continuous*, forced ventilation with blowers of sufficient capacity to keep all the air moving freely.

As a corollary of the facts here brought out, we should avoid designs which provide for gas space within the digestion tank; avoid vents or overflows which may provide connection with the atmosphere; and avoid unnecessary mechanisms, such as stirring devices, which may, at any time, require mechanical attention.

JOHN R. DOWNES,
Supervising Engineer,
Plainfield, Joint Sewage Works.

WATER WORKS AND SEWERAGE TOPICS AT CONVENTION— AMERICAN SOCIETY MUNICIPAL ENGINEERS

ONE entire day of the 37th Annual Convention of the American Society of Municipal Engineers held at Pittsburgh, Pa., Oct. 19-23, was given over to papers and discussions on Water Works and Sewerage topics.

Mr. L. R. Howson, Consulting Engineer, of Chicago, presented a comprehensive report as chairman of the Committee on Water Works Practice. The report consisted of a resume by the chairman of valuable contributions from the individual committee members some of whom were present to amplify Mr. Howson's review.

"The Use of Zeolite in Softening Municipal Supplies" was ably presented by **D. E. Davis** of Pittsburgh.

Comparison was made of the two distinctive types of zeolite used in softening practice—(a) that from naturally occurring greensands vs. (b) artificially manufactured or synthetic zeolite made from silicate of soda and alumina. The two were found to be about equal in value. The heavier greensand would remove 3500 to 4000 grains of hardness per cubic foot whereas the more bulky synthetic zeolites would remove more hardness per unit of volume. Since both are sold on a weight basis the advantage based on volume capacities was cancelled.

In practice the salt requirement had been less than 0.5 lb. per 1000 grains of hardness removed. The zeolites used in two plants of 4 and 2 m.g.d. capacities under observation had not lost any of their original efficiency. In one plant manganese had been successfully removed also. The rates of filtration had been held to that employed in gravity sand units, i. e.—2 gal. per square foot per minute.

Results taken from 30 months of operations at the Sewickley (Pennsylvania) gravity type plant indicated that the salt requirement had been 0.378 lb. per 1000 grains of total hardness removed on the average—the maximum being 0.42 lb.

Each cubic foot of zeolite had removed 3600 grains of hardness at a cost of $1.61 per million gallons for each grain (17.1 ppm.) removed. This was accomplished with salt costing $8.50 per ton delivered in the bins at the plant. The zeolite loss due to back washing, disintegration, etc., had been about 1.5 per cent by volume.

By comparison the zeolite plant had several distinct advantages over a lime-soda softening plant both in first cost for construction and in operating costs. In lime softening the chemical cost with hydrated lime at $13.00 per ton would compare with salt at $7.50 per ton for equal hardness removal by zeolite.

Reduction of 200 parts of hardness to 60 parts entails a cost of $40.00 per million gallons treated, which would represent an added cost for soft water over ordinary filtration equivalent to about $2.25 per capita per year. The estimated soap saving amounts to $10.00 per consumer.

The zeolite method has the advantage of being about as "fool proof" as it is possible to make water treatment; it is clean and non-complicated.

Mr. Howson added a statement which had been given out following a survey by the Illinois State Water Survey, viz.—that soap savings alone would generally amount to three times the expense incurred for water softening.

"The Other Side of the Public Works Budget"—C. E. Ridley, Executive Secretary, International City Managers Association.

Mr. Ridley's prediction was that the tax payers in the future, as well as budget officials, would require more adequate accounting of funds expended on public works and their operation than previously had been the case. Forecasting, planning and performance by departmental heads would be more important if requested funds were to be forthcoming or continued.

Sanitary work is of a nature that can be perhaps the most easily evaluated of any municipal endeavors and that he believed that rewarding employees according to performance was to become an essential factor in municipal operations. Mr. Ridley did not, however, go into the subject of how such rewarding might be managed in the representative American municipality.

"Economics of Waste Disposal"—Dr. E. E. Butterfield, Forest Hills, L. I.

Dr. Butterfield believed that it will be proven that heat values procurable by burning garbage and sewage solids will be sufficient to produce the power requirement to operate even the most costly system of sewage treatment. Further, the heat value in refuse is about three times that obtainable from garbage and therefore the municipality could without question produce more power than required for the maximum power consumer in the sewage treatment field—the activated sludge process.

The practical side of the problem resolves itself into a matter of combustion control and reduction of water content of garbage by pre-drying and that objections to steam generation at incinerator plants are merely superficial. Examples of the use of high moisture low-grade fuels for power generation were cited in order to indicate the feasibility of his plan.

In the discussion of sewage treatment, Dr. Butterfield went into the reaction products which resulted from chlorination. The reaction between chlorine or hypochlorite and degradation products from protein substances resulted in aldehydes being the end products produced. The process was, as far as it went, not dissimilar to biological oxidation effects on amino-acids and many fatty materials.

"Sewerage & Sanitation Committee Reports"—A. P. Learned, Consulting Engineer, Kansas City, Mo., Chairman.

Mr. Learned's report traced the history of sewage treatment developments from 1887 to date. The introduction of mechanical equipment into sewerage practice together with developments in heating separate digestion tanks had done much to advance the art.

While activated sludge has been further perfected and is popular the sprinkling filter had not lost favor and was particularly attractive in coping with industrial waste bearing sewage.

Chlorination had proved to have application other than for disinfection alone and perhaps its most effective added use was for odor control and relief of filter ponding.

Pre-aeration of settled or crude sewages has merit in increasing sedimentation efficiency, and "sweetening up" the sewage. Developments during the year had consisted largely of refinements rather than radical departures in practice.

In discussing the report **George Gascoigne,** Consulting Engineer, Cleveland, called attention to the need for further study of sludge gas utilization in power generation. Although gas engines at Rockville Center, L. I., had consumed 20 cu. ft. of sludge gas to produce one brake horsepower and those at Charlotte, N. C., had required 22 to 24 cu. ft. per horsepower produced, it should be possible by changing to low speed engine design to produce that power with 12 to 14 cu. ft. of gas. Sewage plants abroad are making more effective use of this gas than we have done in America.

"Settling Characteristics of Activated Sludge"—D. W. Townsend, Engineer, Milwaukee Sewerage Commission, Milwaukee, Wis.

Mr. Townsend ventured the opinion that the sludge separation in activated sludge treatment of sewage constituted the most important stage of the treatment.

In the final settling tanks about ½ ft. per minute lineal velocity would appear about the maximum allowable, if good settling was to result. A properly aerated mixed liquor effluent leaving the aeration tanks containing 2000 to 3000 parts per million of suspended solids by weight should settle out sludge during 30 minutes of quiet standing to between 200 and 250 c.c. per liter, i. e., 20 to 25 per cent by volume.

In designing final settling tanks the units should be considered in two parts. The retention period calculated for the upper (mixed liquors) zone, representing 50 per cent of the volume of the tank, might be 3 to 4 hours whereas the lower (sludge concentration) zone should have a shorter detention period. The rate of sludge removal and the sludge mechanism efficiency would therefore prove of importance in securing best operating efficiencies. Concentration effects and rapidity of sludge removal constitutes the important factors.

The quantity as well as quality of suspended sludge particles had been shown to have an important bearing on efficient precipitation of activated sludge. Bulking of once settled out sludge is a serious matter and occurs more frequently during cold weather when there is a low ebb of biological activity in aeration tanks than at other times. Increased air application had proven helpful to overcome Winter bulking.

In plant operation a gentle squeezing action obtained by a mechanism travelling slowly on the bottom of the tanks seems to be the most effective means of causing activated sludge to separate from its surrounding water and thus coalesce into a more dense sludge. Thereafter the more promptly the sludge can be withdrawn the more satisfactory are the results from the final settling process. Too much of this mechanical action on the other hand tends to produce a re-dispersion of the thickened sludge.

"Explosions in Sewers and Sewer Maintenance"—J. J. Jessup, City Engineer, Los Angeles, Calif.

In the absence of the author his paper was read by **Mr. Guy Brown.** Mr. Jessup stated that sewer ventilation was a real problem because of odor nuisance created. Explosive mixtures had been detected in 21 per cent of the 1500 manholes tested on one survey in Los Angeles. Oil refineries had been responsible. The instrument employed had been a combustible gas indicator put out by the Union Carbide Co.

Los Angeles had experienced several sewer-gas explosions. One, two years ago, had blown 30 manhole covers 25 ft. into the air. In another, leaking gas mains had resulted in an explosion which had destroyed 350 ft. of sewer; and broken gas mains had also been responsible for explosions. The U. S. Bureau of Mines published investigations of sewers, dated Oct., 1929, and May, 1931, for explosive contents were referred to in which one survey of 1760 manholes inspected disclosed explosive mixture in 107. The London sewer explosions of 1928 were also referred to. Mr. Jessup warned that observing odors will frequently not reveal presence of explosive mixtures because the gas is frequently composed of carbon monoxide and hydrogen, neither of which has an odor.

"Mechanical Handling of Sewage Solids"—E. B. Besselieve, The Dorr Company, New York City. This very well written paper was presented by **Mr. Darby** and contained descriptions of the more recently perfected mechanical equipment manufactuded by The Dorr Company. The several advantages of automatically cleaned bar screens were set forth among which the most important seemed to be the reduced open area of screen required. The value of grit removal and washing by the "Dorr-Detritor" was also set forth very effectively. The author concluded with the prediction that vacuum filters for drying digested sludge appeared to have merit and warranted future consideration on several grounds.

Prof. John C. Gregory in discussing the paper said that he believed that more mechanical equipment would be used than even now is the case. He announced the beginning of extensive experiments at Baltimore and Columbus sewage plants wherein vacuum filters are being used in conjunction with ferric-salts as sludge conditioning agents for the purpose of dewatering digested sludge. The less well known "Genter" filter manufactured by the Bartlett-Hayward Co. of Baltimore was being compared with the better known Oliver filter. It seemed probable that the sludge cake might be incinerated and the whole process replace sludge drying beds eventually.

The sludge from the digestion tank (94 per cent water) had required only 8 lb. of ferric chloride per 100 lb. of bone-dry solids handled as sludge, i. e., 0.48 lb. per 100 lb. of the wet sludge.

In reply to questions, Prof. Gregory said that regardless of incineration the filtration would be practical and that the cake contained but 72 per cent moisture on the average.

Mr. Beaumont of Philadelphia said that from experience with oil wastes and other wastes on digestion he hoped that incineration would prove a practical means of sludge disposal without having to resort to digestion.

Mr. Bachmann added that vacuum filtration would make it feasible to give sludge a 30-day digestion whereas now 3 months were required if drying is accomplished on sand beds. Chicago is now oper-

ating an experimental plant on a 30 day period of digestion.

"New Developments in Sludge Digestion Tank Construction"—J. L. Mason, The Hardinge Company, York, Penn.

Mr. M. C. Fleming was the reader of Mr. Mason's paper which described the advantages of the use of dome-type construction of digestion tank covers and that tanks so covered might be built as large as 140 ft. in diameter. The segment of a hemisphere was used as the shape of the dome with a maximum center height above the plane equal to 1/10 the diameter. When the tank is in operation the dome is kept under a hydrostatic head. Two tanks of 50 ft. diameter had been built at Rockford, Ill., and five were under construction at other points.

"Trade Waste Treatment"—M. J. Blew, Department of Public Works, Philadelphia, Pa.

Mr. H. M. Beaumont read the paper prepared by Mr. Blew in which the keynote struck was that industry should not be excused in stream pollution violation merely on the plea of lack of knowledge concerning a method of trade waste treatment.

Industrial plants were in themselves frequently burdened if not injured by stream pollution by other industrial operations above them.

The several basic principles of trade waste treatment were discussed including precipitation and oxidation by chemical means rather than attempting biological treatment in most instances.

The return of "white-water" in paper and board mills and the re-use of the water which resulted most frequently in economics was stressed as one way out for this industry.

The wool industry had likewise found that re-use of the wool-scouring waters had effected savings and effectively reduced stream pollution and only 10 per cent to 20 per cent make up water had been required.

"The Lime-Chlorine Process in Sewage Treatment"—W. V. Brumbaugh, National Lime Association, Washington, D. C.

Mr. Brumbaugh reviewed the development of the "lime-chlorine" process and its several advantages over and above ordinary chlorine application to sewages.

The primary advantages had been the increased chlorine efficiency for which very probably the production of chloramines from the ammonia in the sewage had been responsible. The chlorine requirement had been reduced sufficiently to more than pay for the lime involved and the residual chlorine had proven to be very persistent. Furthermore there were many other advantages which taken alone were not appreciable whereas collectively were important. That the alkaline hypochlorite produced by the process when applied at points ahead of the activated sludge process seemed meritorious, as evidenced by the English experiences with bleaching powder so applied to septic sewage and poor activated sludge. Attention was also directed to the use of the chlorinated lime emulsions for applications at various points around sewage plants without chlorine loss or difficulties from corrosion of containers or pipe lines.

It seemed that we were getting back to the bleaching-powder idea but without the nuisance involved in using it and that the feeding of lime and chlorine were well understood and offered a clean cut and non-cumbersome method of preparation of hypochlorite.

At Baltimore during the past Summer the process had been employed at the sewage plant to control algae growth out in the river. Roughly, 3000 lb. of chlorine and about 4000 lb. of hydrated lime had been applied daily to secure residual chlorine in the effluent from the plant. No difficulties of consequence had been met and no accidents had happened with this process in the hands of men previously unfamiliar with chlorine handling.

At Dayton, O., the process had been effectively used at the sewage works for odor control and that other advantages had appeared unexpectedly.

In discussion of Mr. Brumbaugh's paper **M. W. Tatlock,** superintendent of the Dayton Sewage Treatment Works, was given the privilege of the floor.

Mr. Tatlock related in an excellent manner the several improvements which had been noted in the operation of the Dayton plant subsequent to the beginning of prechlorination of the crude sewage wherein the "lime-chlorine" process had been employed.

The most benefit had been odor control and improved performance of the Imhoff tanks, in that the incipient foaming had been corrected. The effluent had improved in consequence and the formation of scum under the gas collection bells and flow chambers had been reduced to a remarkable degree and that less sludge bed capacity had as a consequence been required for handling scum and skimmings. The reduction in labor on the tanks and sludge beds had resulted in a monetary saving and that sludge stayed down in the Imhoff tanks. An interesting observation had been that all of this was secured with chlorine less than sufficient to satisfy the chlorine demand of the sewage during the high flow periods.

The reduction of the oxygen demand of the tank effluent with prechlorination had been surprisingly high and consistent. The overall B.O.D. reduction by the plant prior to chlorine application had been 47 per cent and that had been increased to 67 per cent shortly after chlorination started. Recently an added load to the plant had reduced this to 55 per cent. The cost of the treatment had been $2.19 per million gallons with chlorine applied at the average rate of 8.88 parts per million and hydrated lime at 1.3 times that, viz., 11.6 ppm.

The December issue of WATER WORKS AND SEWERAGE will carry an especially prepared article by Mr. Tatlock which gives the results secured, cost data, etc., in a very complete manner.

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Sewage Flow from Institutions

In a discussion at the 1931 Conference of the Maryland-Delaware Water and Sewerage Association Dr. Willem Rudolfs, Chief, Department of Sewage Research, New Jersey Agricultural Experiment Station, stated that for the last year they had been measuring, accurately, two schools, one of about 125 pupils and the other about 240 pupils. They found that the flow in the two schools varies between 8 and 15 gal. per pupil. They also had occasion to measure seven institutional flows, and found that the flows are considerably higher than the average flow from a town. For an insane hospital with about 4500 inmates the flow was about 200 gal. per patient. For a tuberculosis hospital, the flow was 175 gal. per person. For smaller and other institutions, they all run between 175 and one ran up as high as 290 gal. per person. They also had accurate flow measurements over a period of three months from an industry employing 2300 people. They find that an average flow from the industry, separate from any waste, varies between 32 and 40 gal. per person working in the industry.

EDITORIALS

Sewage Plants and Odors

WE know a very clever writer and capable operator of sewage plants who once wrote an article on "The Three C's of Odor Control." These mysterious C's were nothing more than care, cleanliness and chemical treatment.

A short while ago somewhat of an "odor hound" in presenting a talk on the causes of odors around sewage plants made reference to those odors which were odors in fact and then referred to another class of odors—"pyschological odors"—which were visible and could be "smelled" through the eyes. In this last remark indirect reference was made to the lack of cleanliness and neatness around the plant as having a distinct reaction on the nasal imagination.

A layman suspecting that odors are being produced at a sewage plant will be doubly convinced of the correctness of his impression should the visible evidence be in sight at the time of his visit—and the news spreads. On the contrary should the plant be in a neat and clean condition with lawns and surroundings well kept and flowers and shrubbery well arranged then at least psychological deodorization has been effected and that is ofttimes as important a process as is actual deodorization.

There are a few sewage treatment plants in America which are blessed with the aid of nature in supplying "psychological deodorization." The locations of these are such that the natural beauty of the approach and surrounding serve to break down the resistance of one's imagination and the layman feels compensated for his visit to the plant, previously conceived as being nothing more than an unpopular necessity and the news spreads—but this time it is of a different sort.

In this issue there are shown illustrations of a sewage treatment plant just recently completed among lovely surroundings on the grounds of Sweet Briar College in the foothills of the Old Dominion. In building this plant the engineers were careful to preserve the natural beauty of the surroundings. To examine the illustrations of this plant is to realize that in sewage treatment nature can materially assist science when it comes to the use of processes which depend upon the reverse action wherein science is called upon to assist nature for its effectiveness.

Beautification of sewage plants is becoming increasingly popular and represents money wisely invested if the municipal officials are anxious to show the taxpayer that he is spending his money on something worth while.

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Conferences and Short-schools

IT was indeed impressive to listen to the presentation of a recent paper by a superintendent of filtration in which a review of his "Twenty-five Years in Water Purification" included a glowing tribute to "The light that dawned" in 1921 when a conference on water purification was founded in his state.

Both the speaker, Thomas H. Tristram—who may justly be termed an "old timer"—and the condition of the plant at Lorain which he manages, exemplify the value which conferences and water works short-schools may have in advancing the art and science of water purification.

No little credit is due the founder of the Ohio Conference on Water Purification, F. Holman Waring,—then assistant to W. H. Dittoe the chief engineer of the State Department of Health—for his foresight in this matter and his energizing ability. Not alone have the published Proceedings of the Ohio conferences been enlightening and stimulating to its members: they have been valuable to the profession as a whole and he who possesses a complete set of the Proceedings of the Ohio Conferences should count himself fortunate.

The effectiveness of the conferences can best be appreciated by seeing at first hand the spirit and interest displayed and by knowing the membership and the plants under their supervision. It is likewise of some significance that the operators of Ohio plants have remained for exceptionally long periods at one location with appreciation and advancement.

About the same time that the Ohio Conference was founded a water works short-school was organized in Texas and sponsored by the State Board of Health under the guidance of V. M. Ehlers its chief engineer. To visit one of the Texas schools, held annually, is to learn what can be accomplished with mostly "green material."

These pioneers in educational work in the water purification field can look back with much satisfaction on their endeavors. That such conferences and short-schools produce results can be proven by the fact that few if any of the individual states are now without some similar type of organization.

The latest development in this direction is the establishment of a Short-Course for Water Works Operators and Superintendents in Rutgers University at New Brunswick, N. J., where there has been held a similar course for sewage works operators annually for the past three or four years.

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Unemployment Relief Scheme

WORTHY of note is the scheme proposed by Malcolm Pirnie, as Chairman of the New England Water Works Association "Committee on Employment," which will if carried through produce work for the unemployed and do away with the unproductive "dole" now being proposed to relieve the unemployed.

This proposal presented in the form of a resolution by the Committee composed of Malcolm Pirnie, Stephen Taylor and George Brehm, was accepted and endorsed by the Association Oct. 1st at Boston and appeared in our October issue.

Essentially the plan calls for money raised by bond issue in individual communities on which interest during the first three years will be paid by the State out of general taxation.

L. H. Enslow

The Pump that protects their Health

Health authorities agree that civic welfare is directly dependent upon a pure, uncontaminated water supply. Deep drilled wells provide water of highest quality. Also less variation in quantity is assured by the deeper installations. Pomona Water-lubricated Turbine Pumps provide the most economical method of lifting underground water. No oil is used below the surface. Important features which make these pumps outstanding are: Lower pumping costs; positive protection against oil contamination afforded by water lubrication; simplicity of construction giving longer pumping life and better service; Goodrich Cutless bearings, eliminating vibration and assuring longest bearing life even in wells carrying a heavy sand-content.

Distributors, factory representatives and service facilities in all principal cities. Name of nearest one and Bulletin on request.

Pomona Pump Co., Pomona, Calif.

POMONA

WATER LUBRICATED

TURBINE PUMPS

PITTSBURGH DES MOINES

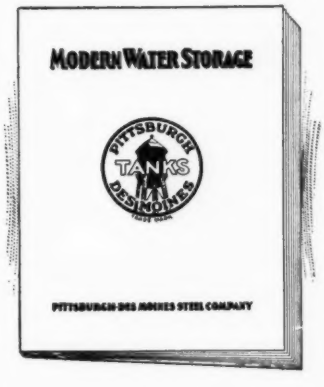
Modern Filtration Plant completed in July, 1931, for the City of Findlay, Ohio. The Consulting Engineers were H. P. Jones and Company, Toledo, Ohio.

Two "Pittsburgh-Des Moines" Tanks Elevate the Water at Findlay's Filtration Plant

The smaller tank at the left holds 40,000 gallons and stands 48 feet to the top; the larger tank holds 500,000 gallons and stands 150 feet to the top.

These two "Pittsburgh-Des Moines" units assure the water mains of Findlay an ample supply at improved pressures—even during periods of peak demand. They also permit a simplified pumping schedule, and guarantee steady adequate service during interruptions in pumping for repairs or replacement work. The increased pressure guarantees plenty of water to outlying districts and to the newly built-up sections of the city.

QUALITY PITTSBURGH TANKS DES MOINES **TANKS**



Write for NEW CATALOG—*Today!*

"Modern Water Storage", our new catalog, has just come from the press. It contains 28 pages of reliable information, interesting photographs, authentic engineering data and "Pittsburgh-Des Moines" specifications on various types of elevated tanks, penstocks, pipe lines, standpipes, steel reservoirs, treating plants, and complete water systems.

Interested municipal and industrial executives may obtain a copy by addressing our nearest office.

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WITH THE MANUFACTURERS

Dresser Mfg. Co. Forms Canadian Company

Another addition to Canadian industries is listed with the announcement that a Dominion Charter has been granted and the organization completed of the Dresser Manufacturing Company, Ltd. This is a subsidiary of the S. R. Dresser Manufacturing Company of Bradford, Pa., manufacturers for the past half century of the well known and widely used "Dresser" line of pipe couplings, leak clamps, sleeves and fittings for use on pipe lines of all sorts.

The new company has been formed in an effort to place even greater facilities for service at the disposal of the many Canadian users of Dresser products, and to arrange for the manufacture in Canada of a considerable part of the Dresser line.

The head office is already established at 32 Front Street, West, Toronto, Ontario, where all future Canadian business will be handled under the direction of D. B. McWilliams.

Mr. McWilliams is a member of the Executive Committee of the Canadian Waterworks Equipment Association, and is well known to engineers and pipe users throughout Canada through his long experience as a Canadian distributor.

R & H Personnel Transfers

The following members of the research staff of The Roessler & Hasslacher Chemical Co., Inc., have been transferred from the plant at Perth Amboy, N. J., to the Niagara Falls, N. Y., plant within the past three months: Dr. Sterling Temple, Dr. B. S. Lacy, Dr. A. M. Muckenfuss, Dr. J. F. Reichert, Dr. C. J. Wernlund, Mr. A. T. Hawkinson, Mr. A. W. Rudel, Mr. J. M. Wainscott, Mr. H. A. Bond; other transfers to the Niagara Falls plant include: from Perth Amboy—Mr. P. M. Paulson, patent specialist, and Mr. M. Marean, librarian; from the New York office—Mr. I. L. Ressler, entomologist.

C. B. Coldwell Transferred to Ft. Worth Office of International-Stacey Corp.

Mr. C. B. Coldwell who was formerly located in Chicago has been transferred to the Ft. Worth office of the International-Stacey Corporation. He has been placed in charge of the sales of the Roots-Connersville-Wilbraham Division line of R-C-W rotary positive blowers, meters, gas pumps and exhausters, Hayton centrifugal pumps and blowers and the Stacey Bros. Gas Construction Division's Telescopic and Stacey-Klonne dry seal low pressure gas holders and Stacey "Bullet" high pressure gas holders. The International-Stacey Corporation offices are located at 1309 Aviation Bldg., Ft. Worth, Texas.

W & T Exhibit Stresses Importance of Ground Water Sterilization

Pollution hazards of ground water supplies was the theme of an interesting display by Wallace & Tiernan at the recent A. P. H. A. Convention in Montreal. A series of transparencies diagrammatically indicated the causes and paths of well water pollution responsible for such outstanding outbreaks of water borne diseases as occurred at Santa Ana, Calif.; Helena, Mont.; Salem, O., and others. Terse but pointed copy, displayed through the use of a mechanically self page-turning book, drove home not only the causes but the results of these epidemics and presented a clear case for the company's contention that "All Well Waters Should be Chlorinated."

Chicago Pneumatic Tool Co. Forms Service Club

The CP Quarter Century Association was formed Oct. 1, 1931, to include all present employees of Chicago Pneumatic Tool Co. and its affiliates in its several manufacturing plants and numerous offices throughout the world, who have completed 25 years or more of uninterrupted service. Seventy-five were eligible at that time and their total years of service numbered 2,112. A suitably engraved Certificate of Membership and a specially designed solid gold pin was presented to each member. The active male employee with the longest term of service in the United States is Mr. Louis H. Brueggemann, now employed at the Detroit, Mich., plant and whose service dates from April, 1898. In foreign countries, the active male employee having the longest term of service is Mr. Horace P. Marshall, present manager of Leeds, England, office whose service dates from April, 1896. The active woman employee in the United States having the longest term of service is Miss Florence Aldcorn of the New York sales office, whose service dates from March, 1900. In foreign countries, the active woman employee having the longest term of service is Miss David of the Cardiff, Wales office, whose service dates from September, 1905. As others become eligible, they will be enrolled in the association and presented with the Membership Certificate and pin.

Bennett S. Chapple, Jr., Appointed Manager-Director of the Armco Distributors Association

Bennett S. Chapple, Jr., has been appointed manager-director of the Armco Distributors Association. He succeeds G. W. Breiel, assistant manager of Armco's Galvanized and Long Terne Sales Department, whose increased responsibilities necessitated his relinquishment of the managing directorship.

Chapple attented Antioch College at Yellow Springs, Ohio. He was a member of the first cooperative work-and-study class ever organized by that institution. After graduation he became a member of the staff of the Geyer Advertising Agency, and later became an assistant store manager for the F. W. Woolworth Co. In 1928 he joined the Armco organization as a member of the Sales Development Department, and ultimately became executive secretary of the Armco Distributors Association. In these positions he acquired experience in sheet jobbing practice and general business methods which will be invaluable in his new responsibilities.

Francis D. West Rejoins The Permutit Company

After about a year and three-quarters as manager of sales of the Paradon Company, Mr. West has returned to The Permutit Company as district sales manager with headquarters at 712 Brisbane Building, Buffalo, N. Y. Mr. West was associated with The Permutit Company from 1918 until 1930, and has had very broad experience in the treatment of industrial water supplies. His return to The Permutit Company is effective as of October 1, 1931.

Announcement

Chester E. Albright has recently announced the dissolution of the partnership of Albright & Mebus, of Philadelphia, Pa., and the organization of Albright & Friel, Inc., consulting engineers, with Mr. Albright as president and Francis S. Friel, M. Am. Soc. C. E., as vice-president and treasurer. The new corporation will practice general consulting engineering, specializing in municipal work, including water supply and sewage disposal. In 1890 Mr. Albright opened an office in Philadelphia for the practice of civil engineering and in 1904 he established the firm of Albright & Mebus. At one time he served as chief engineer of the Bureau of Surveys of the City of Philadelphia. Mr. Friel was associated with Albright & Mebus from 1922 to the time of the dissolution.

WATER WORKS AND SEWERAGE

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A GILLETTE PUBLICATION

LIME-CHLORINE TREATMENT AT DAYTON, OHIO

M. W. Tatlock

By M. W. TATLOCK

Superintendent, Dayton Sewage Treatment Plant

THE Dayton sewage treatment plant provides primary treatment only. It consists of circular detritus tanks equipped with Dorr clarifiers, Imhoff tanks with gas collection and glass covered sludge beds. The bottom concentrate from the detritus tanks passes through grit channels, equipped with Link-Belt continuous flight grit removers, and thenthrough Dorr screens. The screenings removed are pressed and burned in an incinerator burning Imhoff tank gas. This gas is also used to heat the detritus building, the administration building, the Westwood pumping station, the hot water heater for the chlorine evaporator, and is also piped to the club-house on the Fairmount golf course for heating the building and shower water. The landscaping of the grounds was included in the general contract price. Water lines for all plant use, including lawn sprinkling lines, are connected to the city water mains.

The plant (See front Cover) is located about 3½ miles from the center of town on the east side of a 550-acre tract of land purchased prior to plant construction. All the tillable land (approximately 160 acres) is given over to agricultural crops which are fertilized with the plant sludge and another 120 acres lying directly north of the plant have been converted into an eighteen hole municipal golf course. Sludge is also used there on the fair-ways. The plant was placed in operation in November, 1929, and during the summer of 1930 some complaints of obnoxious odors were reported to the City Manager's office. Since the city officials were very definitely committed to a program of sewage disposal without nuisance to anyone, last December, F. O. Eichelberger, City Manager, asked what could be done to relieve the complaints and at what cost.

It has been well established in sewage plant operation that the chief cause of obnoxious odors is hydrogen sulphide and that chlorine will react immediately with it to form hydrochloric acid and free sulphur. In addition the partial sterilization secured delays further production of hydrogen sulphide thus preventing odors as well as destroying them. The reply to the manager's question then, was that the application of chlorine would eliminate the odors and it could be done at an estimated daily operating cost of $1.40 per million gallons treated, if applied 12 hours daily, or $2.50 per million gallons if applied 24 hours. The approximate estimated cost of the necessary buildings, the chlorine and lime feeding equipment was $12,000. Authorization was given to proceed with the work.

Laboratory investigations were begun to determine the chlorine demand of the sewage and inquiries were made to find what experiences elsewhere had indicated the most efficient process of application to be. Linn H. Enslow, of the Chlorine Institute, was asked for advice, and after consideration of all phases of the question, the lime-chlorine process was chosen as most likely to produce the greatest results at the least cost. The plan, in short, being the addition of a water solution of

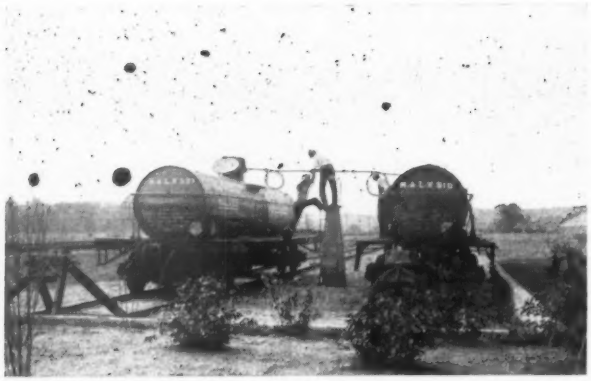

Fig. 1.—Tank Cars of Chlorine (15 Tons Each) Being Placed in Service at Sewage Works, Dayton, O.

chlorine gas to a "milk of lime" suspension to produce alkoline calcium hypochlorite, which then has to be pumped into the sewage force-main ahead of the detritus tanks. The enginering staff of The Mathieson Alkali Works and The Wallace and Tiernan Co. also gave valuable assistance in working out the details of the plant.

A chlorine house was built with sufficient room on the ground floor for storage of a 25-ton car of lime. All of the chlorine equipment was located below in the basement. Chlorine is purchased in single unit tank cars (See Fig. 1) which are set on duplicate sidings served by a single unloading riser pipe connected through a 1 in. extra heavy genuine wrought iron pipe line to convey liquid chlorine to the chlorine house. This line is laid in an 8 in. vitrified split tile, 12 in. underground. Test manholes are located every 50 ft. along this line for testing for leaks or repairs. The liquid chlorine is fed into an evaporator (See Fig. 2) to insure the delivery of gas only to the chlorine machines. Hot water is delivered to this evaporator by a circulating pump from a small boiler heated by Imhoff Tank gas. This boiler is equipped with thermostatic control and the evaporator has an automatic cut-off valve to stop the circulation if the temperature should become too high due to failure of the boiler thermostat. Duplicate chlorine gas lines are provided between the evaporator and the chlorine machines. These are also of 1 in. extra heavy genuine wrought iron pipe. The individual lines to the chlorine machines are trapped by drop pipes serving as condensate reservoirs to avoid the delivery of liquid chlorine to the machines.

The lime machine was originally purchased for pH control. It is a Gauntt dry feed machine, fed through a hopper extending into the lime storage room above. The machine discharges the lime suspension into a 6 in. cast iron line leading to a hoppered bottom, 4 ft. square, hypochlorite solution tank of concrete construction. As the lime suspension passes through this line the chlorine solution from the machines is introduced through hard rubber inlets screwed into the cast iron pipe (See Fig. 3). A constant operating level is maintained in the solution tank by means of a float valve on a water line connected to the city mains. If for any reason the water level in this tank becomes too high, an overflow pipe is provided that leads to a gravity sewer. This overflow line also carries the tray overflow from the chlorine machines. The air relief valves on the chlorinators and the solution lines are vented through a stack to the outside of the building. This stack has an exhaust fan set at the floor to free the room of chlorine, should leakage occur. The control switch for this fan is located outside of the room. Gas masks are provided at convenient points outside of the chlorinator room.

Sewage is delivered to the plant through a 54 in. precast concrete force main, so it is necessary to pump the hypochlorite solution against the pressures carried. This is done by two cast iron Worthington pumps (See Fig. 4) which discharge through a 2½ in. wrought iron line leading to a header which connects with the force main. Four 2½ in. flanged sleeves, were cast in a concrete block surrounding the force main and gate valves attached to the flanges. The four hard rubber, 2 in. tubes which carry the hypochlorite solution through these openings into the sewage are each provided with packing glands which are bolted to the valves. These tubes enter the force main at an angle of 45 degrees and extend to the center of the main. They are connected to the discharge line from the pumps by armored rubber hose (See Fig. 5). This arrangement makes it possible to withdraw the tubes without leakage.

Although the original plans for odor control only called for chlorination 12 hours per day, for added advantages, chlorine has been applied almost continuously on a 24 hours basis since July 19. It has not been used on days of any appreciable rainfall. The purpose of 24-hour chlorination was to determine what results could be obtained from chlorination other than odor control. Because of the fact that the plant is nearing its designed capacity any beneficial effects would prove helpful. The results of the plant scale experiments have been most gratifying and the information following is based on total days of chlorination.

The rate application of chlorine has not been varied with the pumping rate or the amount of organic solids.

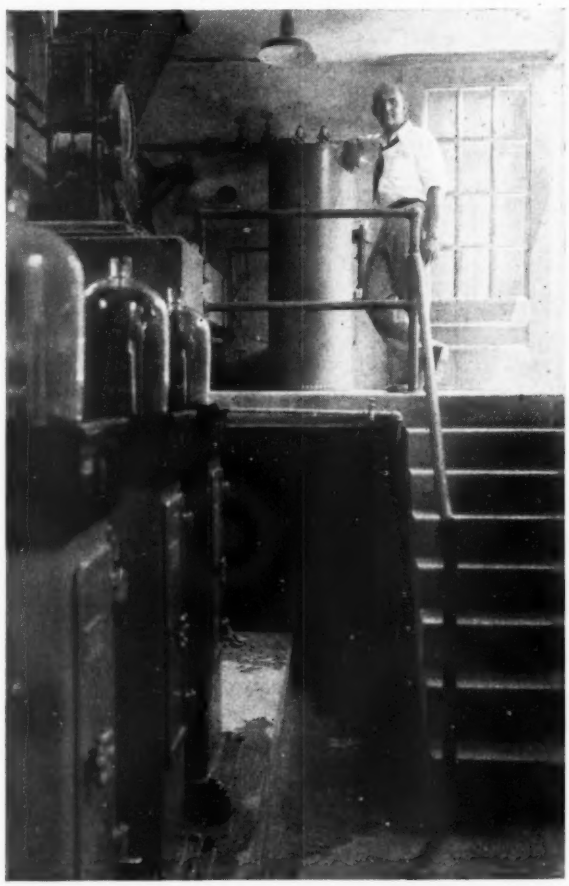

Fig. 2.—Arrangement of Dry Feed Lime Machine (Upper Left) and Chlorinators. The Evaporator Converting Liquid to Gaseous Chlorine Is Located on the Balcony

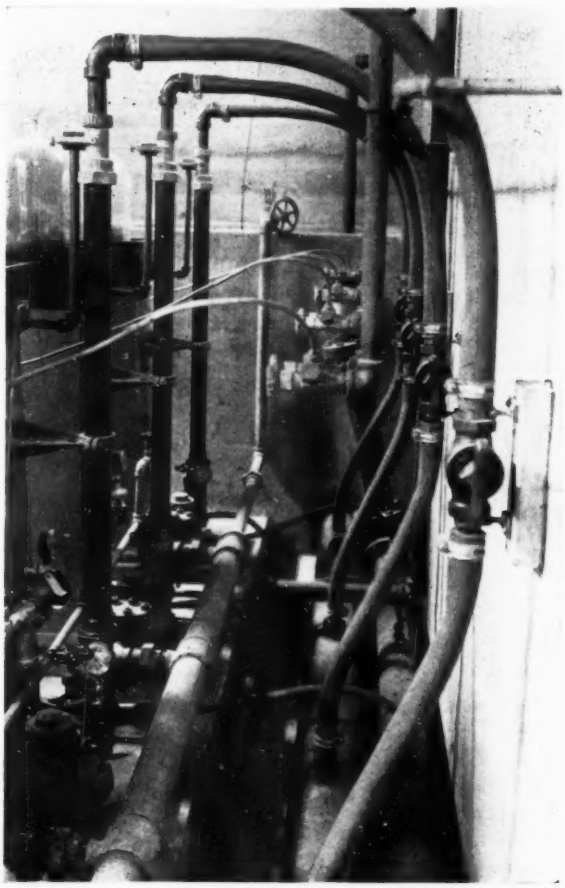

Fig. 3.—Pipe Arrangement in Rear of Chlorinators. Rubber Hose Lines Delivery Chlorine Solution from Machines Into C. I. Line Carrying Lime Suspension to Solution Tank. The C. I. Line Is of Necessity Arranged So As to Flow Full Continuously

Laboratory results show that there has been an unsatisfied chlorine demand from about 8:30 a. m. to 1:00 p. m. even with chlorine application at the maximum capacity of the machines. The dosage has averaged 11 ppm. for an average flow of 23.75 MGD. throughout this period of the day and at a sufficient rate to approximately satisfy all the demand through the other hours of the day. An analysis of the actual pumping rates show that the flows for Saturday, Sunday and Monday are quite different from that of the other four days of the week. The flow on these latter four days is no nearly alike that the average is used. Since the actual rate of chlorine application is constant, the variations in apparent demand following chlorine applications should vary with the flow and has been found to hold true. It is interesting to note that the chlorine demand curves show variations in the organic load which correspond closely to meal times.

The actual results from chlorine application have been measured since Aug. 4, when the new Westwood pumping station went into service. The sewage from this station is very concentrated, running close to 500 ppm. suspended solids. Although its addition raised the average suspended solids from 216 ppm. to 235 ppm. no decrease in the percent of solids removed has occurred. The percentages being 58.5 and 59, respectively.

Chlorination has brought about a marked decrease in skimmings, both on the detritus tanks and the Imhoff tanks. From the detritus tanks the decrease has been from 0.51 cu. ft. per m.g. to 0.35 cu. ft. per m.g. or a reduction of 31 per cent. On the Imhoff tanks the decrease has been from 2.10 cu. ft. per m.g. to 1.27 cu. ft. per m.g. or a decrease of 39.5 per cent. The decrease on the detritus tanks is apparently due to some effect on the colloidal materials in the sewage which leaves the floating material more nearly pure grease as indicated by observation of the material before and after chlorination was begun and opens up a problem for further research. The decrease of Imhoff tank skimmings is due entirely to general improved operation performance which will be discussed later.

During the first seven periods* of this year there was removed from underneath the sloping walls and gas collectors on the Imhoff tanks 3,780 cu. yd. of scum. During the following two periods (the chlorinated period) there was only 90 yd. removed. The average number of days on the drying beds was 17. During the same periods there were removed a total of 7,200 cu. yd. of sludge. The average number of drying days was only 13. Since the sludge contains 22 per cent less volatile matter than the scum, the 3,780 yd. of scum held down in the digestion compartment should become approximately 3,000 cu. yd. of sludge and the number of sludge houses required for drying would be reduced from 42 to 33 a reduction of 9. And since drying the material as sludge instead of scum saves 4 days drying time on each house of scum, its entire elimination is equivalent to the drying time for 13 houses of sludge, which added to the increase due to more complete digestion makes the equivalent of 22 houses less drawings in 9 periods. This being equivalent to 32 for a year, a 16½ per cent increase in drying capacity of the present installation results without any

*The plant is operated on a 13 months calendar, each period is 28 days.

Fig. 4.—Solution Tank (Right Corner) and Pumps Delivering Lime—Chlorine Solution into Crude Sewage Force Main (View from Balcony) Note Ventilation Fan on Left at Floor

additional sludge bed construction. If this additional space were built at the same expense as the present installation it would cost $18,000. The savings on actual removal of the material from the houses in the form of sludge instead of scum is $300, i.e., twelve houses per year at $25 per house.

The observed results on the Imhoff tank performance are less skimmings, no scum withdrawal to the sludge beds, and more material handled at no decrease in efficiency, all of which can be directly connected with the observed effect of chlorination and correlated with the sludge depth in the bottom of the tanks. On two different occasions chlorination has been stopped for 24 hours and in each case the sludge level rose from 1 to ½ ft. in 24 hours and within 48 hours after chlorination began again the sludge had returned to its original level. Such a rise in sludge level is always accompanied by increased skimmings and labor in keeping the gas collection system clean and operating properly. The total

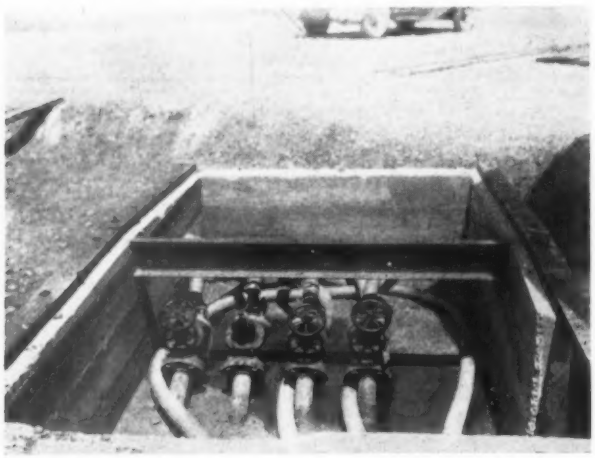

Fig. 5.—Arrangement for Introducing Lime—Chlorine Solution into Force Main

operating savings which can be credited to chlorination is the equivalent of one man day or $4.00 daily.

The Dayton plant was designed to give 35 per cent reduction in B.O.D. During the present year prior to chlorination, the actual removal was 47 per cent. This figure was increased to 67 per cent during the period, July 19 to Aug. 3, during chlorination, but before the more concentrated Westwood sewage was added. Since this additional load was added (9 per cent increase in suspended solids) the percent B.O.D. reduction has been 55; an increase of 17 per cent.

On the whole, and with certain improvements planned in respect to chlorine application, it is felt that the overall results effectively establishes the value of prechlorination for raising the plant efficiency in addition to its efficiency in odor control.

The effects of chlorination, briefly summarized, are:

1. A 31% reduction in detritus skimmings.
2. A 39.5% reduction in Imhoff skimmings.
3. A 16.5% increase in the drying capacity of the present sludge beds.
4. A 17% increase in B.O.D reduction through the Imhoff Tanks.
5. 9% more suspended solids treated with no reduction in the per cent removed.
6. A savings of 22 cents per m.g. sewage treated due to decreased labor.
7. No hydrogen sulphide odors.
8. No reduction in gas production.
9. No slowing up of sludge digestion.
10. An expensive expansion program delayed several years.

The cost per m.g. per day has been as follows:†

Days applied	74
Sewage treated	1660 m.g.
Total chlorine applied	122,776 lb.
Total lime applied	163,400 lb.
Lb. lime per lb. chlorine	1.31
Lb. clorine per m.g. sewage	74
Lb. lime per m.g. sewage	97
Cu. ft. water per m.g. sewage	380

The cost per m.g. per day has been as follows:†

74 lb. chlorine @ $2.115 per cwt	$1.565
94 lb. lime @ $.4925 per cwt	.478
380 cu. ft. water @ $.50 per th	.190
Labor, 1 man @ $4.00 per da	.179
Total gross cost	$2.412
Less labor saved	.22
Net cost per day	$2.19 per m.g.

†These figures are not given as a comparison of the lime-chlorine treatment with any other method of chlorine application. They represent the application of this method of treatment at Dayton, O.

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Institute of Hydraulic Research Opened at University of Iowa

The Iowa State Board of Education has announced the organization of the Iowa Institute of Hydraulic Research at the State University of Iowa. The institute has been organized to afford an agency for the coordination of the talent, facilities and the resources that may be made available at the University of Iowa for undertaking projects of unusual magnitude, scope or complexity in the field of hydrology and hydraulic engineering.

Investigations are conducted under the direction of the operating staff and cooperating engineers. The consultants from the cognate departments of the University faculty are available for counsel, either as a group or singly, concerning aspects of hydraulic problems which involve their respective fields. The practical engineering value of the research undertaken is advanced through the association with the Institute of an advisory committee of prominent practicing hydraulic engineers.

The institute is an integral part of the University and is administered accordingly. It affords a connection through which technical societies, governmental departments, municipalities, industries, power corporations, and other interested parties may effectively cooperate with the University in the field of hydraulic research.

The staff of the Institute is as follows:

Director: Floyd A. Nagler, Professor of Hydraulic Engineering; Associate Directors: David L. Yarnell, Senior Engineer, Bureau of Agricultural Engineering, United States Department of Agriculture. Martin E. Nelson, Assistant Engineer, St. Paul District, United States Engineer Office. Associate Engineers: Frederic T. Mavis, Associate Professor of Mechanics and Hydraulics. Joseph W. Howe, Assistant Professor of Mechanics and Hydraulics. J. Stuart Meyers, Research Assistant in Hydraulics.

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Operating Costs Reduced at Brantford, Ontario, Filtration Plant.—From a letter received from N. J. Howard, of Toronto, Ontario, we quote the following paragraph:

"Have just completed a consulting job at Brantford, Ont., putting in prechlorination and reducing operating costs for chemicals from $4.63 per million imperial gals. to $1.63—a net saving of between $4,000 and $5,000 yearly."

Fig. 1—Concrete Dam Across the Rio San Juan Constructed in 1840 by Spanish Engineers

THE SANTIAGO DE CUBA WATER SUPPLY

By JOHN F. PIERCE

Civil Engineer,
24 Bayley Terrace,
South Weymouth, Mass.

A HUNDRED years of hope, expectancy, anticipation, longing, and desire for an adequate supply of fresh, drinkable water is interwoven into the history of the Santiago de Cuba aqueduct. Throughout the century the people of the second largest city on the Island of Cuba have watched the construction, reconstruction, and improvements of their government-owned water system. Today, as of yesterday, the supply is inadequate and the service is limited.

On the outskirts of the city are huge concrete tanks, tunnels through the mountain, pipe lines and siphons constructed to convey water to that historical port. It is a magnificent engineering project conceived, promoted, and financed by an enthusiastic government but remains unfinished because of the economic conditions of the country.

Commissions and engineers from Spain, the United States, and Cuba, as well as individuals have, during the past 100 years, made studies, proposed subjects, conducted innumerable investigations, and submitted elaborate reports for providing an adequate supply of water. The United States Army contributed their thoughts and plans, based upon investigations made of the surrounding country in 1901, for the solution of the problem. Politicians from the beginning, have promised "water" in exchange for votes.

History of Santiago's Water Works.—The original water system, or aqueduct, was conceived about 1830. In Nov. 1, 1835, the council of the city of Santiago de Cuba received a communication from Senor Don Dionosio Carreno soliciting permission for the construction of an aqueduct in that city. Three years later the Spanish governor granted the concession and the work was commenced. The following year (1839) the concession was transferred to the city where control was retained until the system was taken over by the Central Government on July 1, 1908.

On the rio San Juan, eight kilometers from the city, the first dam was built at the "Paso de la Virgen," between the towns of Cuabitas and Boniato. (See Fig 1.) The cross section of this dam is trapezoidal, 30 meters long and 10 meters high. It has withstood the tropical rains and sunshine for nearly a century and still is in good condition.

The water back of the dam is conveyed to two sedimentation tanks near by. These tanks, constructed of ordinary masonry, are 6 meters by 8 meters by 4 meters. The combined capacity is 103,000 gal. From these tanks the water flows by gravity through a 11-in. cast iron pipe 8,000 meters long to another tank in the city. The capacity of this system is 344,500 gal. per day.

The tank in the city is also constructed of ordinary masonry 8 meters by 16 meters by 4 meters. When first put into service a fountain was attached from which the people obtained the water. There was also a drain from the tank that went through the city down to the bay to supply the water to the vessels. The total cost of this project was $462,000.

After a few years the supply from this river was inadequate for the requirements of the people. The Spanish government sent several commissions of engineers to Cuba, between the years of 1875 and 1880, to study and report on the possibility of obtaining more water for the city. Investigations were made of all of the water basins on the eastern end of the island.

Due to changes in the government in Spain and the political disturbances on the Island it was impracticable to undertake any constructive work to improve the water system. When the American Expeditionary Army entered the city in July, 1898, the only fresh water was the meager supply from the aqueduct constructed in 1838, 60 years before.

U. S. Army Engineers Study the Situation.—The United States Engineer Corps were stationed in Santiago de Cuba from 1898 until 1902. During this time they made improvements to the then existing system as well as studies for an additional supply. In 1901 it was determined, by a venturi meter, that the system was capable of supplying 300,000 gal. daily, or 18.6 gal. per capita.

Due to the necessity of cutting off the supply in the lower section of the city to enable those in the higher section to obtain water, the amount furnished daily was only 162,000 gal. This supply of 9 gal. per capita was reduced to about 5 gal. during the months of March, April and May when the stream flow became negligible.

The army engineers cleaned out the original reservoir, made repairs, and connected it with the distribution system and supply line. By this rearrangement the northern part of the city received its supply from the reservoir and the southern part received its supply from the main pipe. The supply was increased to 300,000 gal. per day.

Field investigations showed that there were three available sources that would meet the requirements of

Fig. 2—Santa Ana Tanks Constructed in 1908. The Water Comes from the Chalons Reservoir through a 20-in. Cast Iron Pipe. In the Center of the Picture Is the Division Wall Which Separates the Tank into Two Compartments of 5,000 Cubic Meters Capacity Each

the city for the next 30 years. The gravity supply from Baconao, which was estimated to cost $2,844,212; that of the Cauto, by gravity, at a cost of $1,451,167, and a supply at San Juan, by pumping, which would require an investment of $408,650.

The latter was recommended and the army engineers prepared plans for utilizing this source. Pumps capable of delivering 4,000,000 gal. daily were to be installed, a force main was to be laid from the wells to the reservoir located near the Cementario Viego, and a high and low reservoir were to be constructed.

Before bids for the construction of this project could be obtained the army was withdrawn. The plans were turned over to the new government and placed in the archives where they remained for several years.

One of the pressing problems of the new Republic was the Santiago de Cuba water supply. The monetary income of the National government was small. No money was available for the construction of a new aqueduct. Time passed. Greater demands were placed upon the water system. The available supply remained relatively constant. The per capita allowance was decreasing.

In 1908 the hopes of the people were raised when they viewed the construction of a new aqueduct six kilometers outside of the city. A masonry dam 140 meters long and 20 meters high was being built across the rio Purgatario, an effluent of the rio San Juan. A storage basin of 1,500,000 cu. meters was to be created. Surely this amount would be sufficient for a city of 46,000 inhabitants.

Then came the laying of a 20-in. cast iron pipe from the dam to the city. The water would flow by gravity with a fall of 15 meters from the top of the dam to the tanks. A distribution tank, divided into two compartments, each having a capacity of 5,000 cubic meters was being built 100 meters from the first, or old, reservoir. (See Fig. 2.) An elevated iron tank with a capacity of 100,000 gal. was being erected. Improvements were made to the distribution system. The dreams of the people almost became a reality.

A Costly Disappointment.—From 1902 to 1909 a million dollars had been spent for investigations and the construction of the "Acueducto Nuevo." With what result? The flow from the new source fell far short of the estimated 5,000,000 gal. per day. During the period of maximum dryness the flow disappeared entirely and in the rainy season reached 2,113,000 gal. per day. Only twice in 13 years (1908-1921) did the reservoir fill to the top of the dam.

To add to their troubles the water that was impounded became polluted. The tropical sun caused the organic matter to decompose rapidly, thus making the water unfit for human consumption. The Secretary of Sanitation, Dr. Plazaola, reported that on one of his visits to the dam the scum on the water had reached a thickness of 60 centimeters. In order that the boat could proceed around the basin it was necessary to separate the scum.

The seepage losses from the basin through the volcanic rock were great. Two tunnels were driven into the embankment, one at each end of the dam to collect the escaping water and to divert it into the discharge pipe. Only a fraction of the leakage was collected by this arrangement.

In 1910 the city experienced a water famine. The rivers became dry, the reservoirs empty. Commercial and industrial life was paralyzed. Electrical service was discontinued for two weeks until water could be obtained for the boilers. Drinking water was brought to the city in tank cars from Guantanamo. The rainy season brought relief but no assurance that another famine would be averted.

Drilled Wells Put Down.—Three years later (1913), when the population had reached 61,513, an increase of 35 per cent since 1907, the government turned to the old valley of the San Juan river for more water. This was the source recommended by the United States Army Engineers 11 years previous.

Here wells were drilled varying in depth from 5 to 30 meters below the surface of the ground. Water was found 6 meters above sea level.

The tubes are perforated and are 0.30 meters in diameter. There are 3 horizontal pipes, each one being connected to 12 wells placed 100 meters apart. The water is forced from the wells by an air compressor into a central collecting basin. Then it is boosted, by centrifugal pumps, through a 27-in. pipe, 3,000 meters long, to the tanks at Santa Ana where the elevation is 72 meters.

Although installed as a temporary measure these wells are contributing their share of water to the city

Fig. 3—Concrete Dam Across the Rio San Juan above the First Dam Constructed at the "Paso de la Virgen." The Water Back of This Dam Is Conveyed to the "Acueducto Nuevo," a Distance of 1,756 Meters, through a 48-in. Concrete Conduit

Fig. 4—Chalons Reservoir, or "Acueducto Nuevo." From the Moving Boat Liquid Chlorine Is Injected into the Water

today. It has been estimated that the daily output does not exceed 2,000,000 gal.

More Commissions and Red Tape.—Following the installation of the wells a commission of Cuban engineers was named to study and report on a plan that would meet all of the present and future requirements of the city.

They spent three years investigating all of the river basins that might be utilized, including that of the rio Cauto. Their report recommended the basin of the rio Baconao. Where 10,000,000 gal. per day were available. This commission estimated that the amount of water required for the city could be obtained more economically from this source than from any other. The water was to be conveyed through a pipe line 0.60 meters in diameter for 74 kilometers to the Santa Ana tanks at a cost of $5,000,000.

This report did not meet with favor by the inhabitants of the city. Fear was expressed that the water impounded would become putrid in the same manner as had the water they were using from the "Acueducto Nuevo." It was pointed out that 20 kilometers of this pipe would have to be laid in ground that was almost inaccessible, thus increasing the cost of the work.

Notwithstanding the objections of the people who were to use the water the Congress of the National Government authorized the expenditure of $2,500,000 for this project on May 22, 1918.

Time passed. The problem remained unsolved. The seriousness of the situation became more acute. The government turned to the United States for advice by inviting Mr. Alexander Potter, Consulting Engineer of New York City, to study their problem.

In 1920, Mr. Potter proposed the utilization of the San Juan basin where the wells were functioning. An artifical basin was to be created which was estimated to increase the yield of the wells to 7,000,000 gal. daily. The people feared contamination of the water due to the low elevation of the valley. No action was taken on the proposal.

Above the first dam at the "Paso de la Virgen," near the town of Boniato, a concrete dam 199 meters long and 9 meters high was constructed. (See Fig. 3.) A concrete conduit 48-in. in diameter was laid from this dam to the "Acueducto Nuevo," a distance of 1,756 meters. The cost of this work was $200,000.

The combined sources of supply failed to adequately meet the pressing needs of the community. Another water famine was experienced in 1923. The rivers for a radius of 40 kilometers of the city became dry. The city was dependent upon the small supply from the San Juan wells.

Renewed determination to solve the problem was expressed by the National Government. Congress passed a law creating a tribunal to receive and consider plans. It was stipulated that the new aqueduct should furnish 150 gal. per day per capita for a population of 300,000 people.

The members of this commission were the Secretary of Public Works, the chief engineer of Oriente Province, an engineer appointed by the Society of Cuban Engineers, an engineer appointed by the "Centro de la Propiedad de Santiago" and an engineer appointed by the municipal bodies of the city of Santiago.

Four plans were presented. All were rejected. One was not complete, one did not meet the requirements, one failed to include sufficient data to justify the conclusions reached, and the fourth one was believed to be impracticable for economic reasons.

The commission recommended that more study be given to the basins of the rios Canas, Cauto, Contramaester, and Mogote. As the project was to be financed by the National Government it was natural that the study be undertaken by the Department of Public Works.

Consideration was also given to the amount of water

that would be a reasonable amount for a tropical city. Exceptions were taken to 150 gal. per capita stated in the law. Members of the commission and independent engineers agreed that 100 gal. per capita daily would meet all the requirements of the city.

To provide this amount it was recommended that a storage basin of fifteen million gallons capacity be created. The population was estimated to be 150,000 30 years hence. They advised the designing of the aqueduct to be elastic so that the supply could be increased to 30,000,000 or 40,000,000 gal., if necessary.

The Secretary of Public Works, Senor Carlos Miguel de Cespedes, submitted a plan in September, 1925. It was proposed to take the water from the rio Mogote by a concrete canal to the rio Cauto, thence to the "loma de Quintero" near Santiago de Cuba. At this location filter beds and distribution tanks were to be constructed.

The capacity of this system was estimated to be 30,000,000 gal. daily. By captivating the upper Cauto and the Canas this amount could be increased by 45,000,000. And the cost? Only ten millions of dollars.

American Engineering Advice Sought.—The report and data were submitted to Mr. Allen Hazen, Consulting Engineer of New York City, for review. In a letter to the Director of Public Works he made three suggestions. First, that the present supply be filtered; secondly, that meters be installed in the city to conserve the supply; and thirdly, that a detailed study be made of the sources near the city with the object of obtaining an adequate supply at a lower cost than that estimated.

Modifications were made to the government plan. The Secretary of Public Works submitted a revised project with the statement that the cost would be $6,000,000. He estimated that the work could be completed within four years.

The Accepted Plan.—The accepted plan provides for the construction of a concrete dam on the river Cauto above the town of Dos Palmas capable of impounding 7,000,000 cubic meters of water.

The water stored by this dam is to be conveyed through a 48-in. concrete pipe for a distance of 7,670 meters to the town of Reposo. Here another dam across the river Canas is to be constructed. The water is to be taken through the Sierra Maestra by a series of tunnels of various cross sections from 1.60 meters to 2.40 meters in diameter and a concrete pipe of 60-in. in diameter to a proposed dam at Corta Calenturas.

From this dam a concrete pipe of 60 inches in diameter will convey the water a distance of 8,982.80 meters to Quinteron hill near Santiago de Cuba. On this hill it is planned to construct a complete filter plant including coagulant house, mixing canal, coagulant tanks, gravity rapid sand filters, slow sand filters, and two concrete distribution tanks having a capacity of 30,000 cubic meters each. The total length of the new aqueduct is estimated to be nearly 35 kilometers.

Connections to the present distribution system is planned for by laying two cast iron pipes of 0.50 meters in diameter.

Rainfall and Runoff.—Rainfall records have been inadequate and of such short duration as to make their usefulness and reliability undependable for this project. A weather bureau was established in Santiago de Cuba by the United States Army in 1899. Their records of rain fall are: 1899, 54.78 in.; 1900, 59.94 in.; 1901, 57.59 in.

Sugar mills and, in recent years, the National Government have been keeping records of the rainfall. Studying the available records for a period of years it is estimated that the maximum rainfall in 94 in., the normal rainfall 46 in. and the minimum rainfall 14 in.

No detailed studies have been made of the amount of run-off or evaporation. Consequently, arbitrary figures have been assumed throughout the hydraulic computations.

It was estimated that the reasonable amount of rainfall to be expected in the storage area and watershed will be 24.6 in. and that the run-off will amount to 20 per cent. The calculations for the volume of storage were based upon a rainfall of 4.5 in. available for the water supply.

Geological Aspects.—Near Santiago de Cuba are found the highest mountains on the Island. The bay breaks into the Sierra Maestra range which extends from Cape Cruz to Guantanamo in an east to west direction. This range has three prominent peaks, widely separated; the Cerro del Oro, 3,300 ft.; La Gran Piedra, 5,200 ft.; and Pico Tarquino, 8,600 ft. North of this range lies the famous valley of the Cauto which extends to the northern coast.

It is the opinion of geologists that the island is the result of a great movement in the late Tertiary time which raised the land above sea level. The pre-Tertiary sedimentary rocks, which form the base, are covered with basalts, diorits, sepertentines, primary and secondary sandstones, limestone, and congolomorates. The top is a great mantle of Tertiary limestone.

Outcrops of diorite are found at the Arroyo de la Sucursal, and between Solis and Arroyo Grande; felsite dikes at Solio, and basalt at La Candelaris. At the proposed dam site, where test holes were drilled, breccia was encountered. The holes did not extend deep enough to determine if the breccia was resting upon primary granite or diorites, or upon sediment or secondary porus rocks.

This section of the island has been subjected to earth movements of slight importance, usually of little intensity and short duration. In the vicinity of Cobre, as well as on the watershed of the rio Contramaestra, the movements have been noticed by the residents. At the latter place earth movement was reported on April 20, 1929. In the city itself, very slight tremors have been noticed.

Progress Being Made.—Up to the beginning of 1928 $2,622,100 had been spent in the construction of the aqueducts and studies for increasing the supply. This amount is divided as follows: Old aqueduct, $452,000; "Acueducto Nuevo," 1908, $510,000; wells at San Juan, $400,000; improvements to existing aqueducts, $380,000, and investigations, $880,100.

In 1899 the population was estimated at 33,935, in 1920 at 70,232 and in 1930 at 80,000. The supply of water per capita did not increase with the population, but on the other hand, it was reduced. At the present time it is estimated that the daily per capita amount available is 26 gal. in the dry season and 58 gal. in the rainy season. The new aqueduct is designed to furnish 150 gal. per capita daily to 144,000 people.

For several years workmen have been engaged in the construction of the new aqueduct. The pipe lines have been laid, siphons have been constructed, tunnels drilled through the mountains and the concrete distribution tank constructed. Twenty-four kilometers of the project is completed. The location of the dam site has not been determined. Filters are yet to be constructed. Connections to the existing distribution system are only on paper.

NOTES ON THE OPERATION OF SEWAGE TREATMENT WORKS

By WELLINGTON DONALDSON

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WE in American may be very proud of the important research studies carried out on sewage and sewage treatment at various points in the country within the last five or six years. The results of this fundamental work are being reflected decidedly in recent plant designs and in improved treatment results by the older and better known processes. It is well to take cognizance also of the very interesting experimental work now being carried on at widely distributed localities with more direct methods, in the effort to secure clarification and reduction of organic matter by the use of paper pulp with or without lime and coagulants, followed by filtration in some form.

Problems in the Activated Sludge Process.—Probably there is more current interest in the activated sludge process than any other established type of treatment, and for that reason some notes on the operation of a small plant of this type are first offered for discussion.

The special feature of note in connection with the activated sludge plant at Tenafly, N. J. is the existence of intermittent sand filters between the clarifiers and the creek. To thoroughly protect a water supply the effluent is chlorinated also.

The difficulties of operation here mentioned are related to the behavior of aeration tanks and clarifiers whereby suspended solids in troublesome amounts have escaped at times over the clarifier weirs, thus causing considerable annoyance and expense for frequent cleaning of the sand filters.

The average solids content in the clarifier effluent for the several months are quite in line with the usual performance of the process elsewhere, but the daily results have been very erratic at times. Sludge "bulking," a phenomena quite commonly reported with the activated sludge process, has been responsible for this difficulty.

What Causes Sludge Bulking?—Much speculation has been made as to the cause of sludge bulking, and the problem needs careful study in order to solve it.

Speaking of Tenafly conditions only, it has been the observation that bulking is always accompanied by an increased if not profuse growth of Sphaerotilus, a filamentous bacterium.

A similar association of Sphaerotilus with sludge bulking has been reported at other places and the trouble has been traced to wastes from distillation of alcohol or other carbohydrate wastes. Observations have led the writer to believe that carbohydrate wastes and other organic substances derived from alcoholic distillation are not in themselves stimulating to Sphaerotilus growth. A more rational view is that carbohydrate wastes having a high oxygen demand simply act as an added load on the purification plant in much the same manner as would a greatly increased population or the addition of many other organic substances.

Sphaerotilus, it should be remembered, is the usual fungoid growth occurring on submerged objects in streams carrying sewage and in localities where one would not expect undue amounts of carbohydrate wastes.

The theoretical aeration time in the Tenafly plant is from 4½ to 10 hours, based on sewage flow plus return sludge. Actually, however, it has been found that an addition of lime to the inlet of the tanks appears in the tank effluent within two hours. This observation leads to the thought that spiral flow tanks short-circuit more than has been supposed and that the persistence of Sphaerotilus growth may be the result of too limited contact between air and sewage solids passing through the tanks.

Lime Application Corrects Bulking.—Available means for controlling bulking have a very practical interest. The use of lime has proven an effective remedy when applied at the proper time and in the proper manner. At the Des Plaines, Sanitary District of Chicago, plant, benefits from the use of lime were noted and it was noted also that no growths of Sphaerotilus occur in artificial culture media having a reaction greater than pH 8.8. Both of these observations have been confirmed by Tenafly experiences. At the first indications of bulking as shown by the sludge condition or by a rising sludge blanket in the clarifier, hydrated lime is fed to the aeration tanks for a period of 6 to 12 hours and in sufficient quantity to maintain a reaction of pH 8.6 to 8.8. The lime is applied at the inlet of the aeration tank and the control pH tests are made at the outlet of the tanks. *Too little lime does no good and too much lime results in an impairment of clarification.* On some occasions lime was not applied early enough or in sufficient amounts to control the situation. Application of lime at the inlet of the clarifiers, though more economical has not given as good results as when added at the inlet of aeration tanks.

The important change in the operation of the Tenafly plant which improved the conditions over those of last winter has been the reduction of sludge carried in the aeration tanks. Between 0.20 and 0.25 per cent dry solids content of the aeration tank liquor gives best results. Under existing plant conditions dissolved oxygen cannot be maintained at the end of the aeration tanks when carrying solids higher than 0.30 per cent. The lower limit of solids that can be carried in the aeration tanks at Tenafly without causing loss of clarification has not been definitely determined.

The Value of "Sludge Index" Determination.—The "Sludge Index" is a coined term used to express the quality or condition of sludge leaving the aeration tanks.

To arrive at the "Index," the dry solids content of the effluent of the aeration tanks is determined by evaporation of a 50 cubic centimeter portion. This figure divided by the percent of solids by volume (30 minute settling) and this result multiplied by 100 gives the "Sludge Index" figure which presents a condition picture of the sludge. An "Index" of less than 1.0 usually indicates an undesirable sludge condition and a likeli-

hood that bulking will soon follow. At Tenafly an index figure in excess of 2.0 has seldom been encountered.

As a result of the studies made of the Tenafly plant operation during the past six months, provision is now being made to install baffles of the Pasadena type in the aerating tanks to reduce short circuiting. There is also being installed a tank for reaeration of the returned sludge which will have a capacity of about 20 per cent of the aeration tanks. The purpose of this reaeration tank is to secure rejuvination of the return sludge, to provide sludge reserve to be used in meeting the inequalities of organic load in the raw sewage as between night and day, and to better cope with unexpected plant loadings.

Drying and Disposal of Activated Sludge.—With increase of sewer connections and population served, the ability of the covered sand beds, to take care of the excess activated sludge became taxed and it became necessary to add filter alum as a conditioning agent to the excess sludge prior to discharge on the beds. From 5 to 7 lb. of ordinary filter alum is added to a thousand gallons of excess activated sludge. The applied rate of dosing is 2.1 to 2.7 gallons of sludge per square foot of sand surface.

The sludge dewaters quickly and is usually removed as a moist cake within 18 to 30 hours after dosing. During the hot weather of last summer, the excessively high temperatures in the glass covered drying house, caused some odors to develop both in the drying house and at the sludge dump. To overcome this nuisance from 1 to 2 lb. of copper sulphate was added to each thousand gallons of sludge in the conditioning tank prior to transfer to the sand beds.

Screenings Disposal.—Another somewhat unusual feature of the Tenafly plant is the disposal of material from the fine screens. The screenings are delivered automatically into an ejector which discharges once or twice a day into one of three compost cells. The cells are concrete bins having good underdrains and covers to exclude sunlight and have proven very satisfactory for small plants. The compost cells are used in rotation, the material in the idle cells shrinking in volume quite rapidly due to decomposition through the agency of moulds. The cells are cleaned about once a year and without any particular offense.

Problems at Other Plants.—Leaving behind the Tenafly problems which have been of chief interest to me recently, brief mention will be made of a few of the operating problems of some of the other plants.

Sludge Handling at New Haven, Conn.—There is an interesting situation in sludge handling at the New Haven sewage treatment works which comprise coarse mechanical screens, a mechanical detritor and clarifiers. Chlorination is practiced during the summer season.

Primary sludge from the three Dorr settling units is pumped daily to elevated steel storage tanks located on the pierhead. After each pumping to the storage tanks, the sludge is allowed to settle and the supernatant is decanted to the inlet of one of the clarifiers. Daily pumpings and decantations are carried out until sufficient accumulation of sludge is on hand to justify barging to sea. The sludge as pumped from the clarifiers to the storage tanks has averaged about 2.43 per cent dry solids while the sludge delivered from the storage tanks to the barge has averaged about 13.5 per cent, thus reducing very materially the quantity of sludge sent to sea. The sludge barge which is a converted oil scow, having four covered steel tanks, makes trips for dumping sludge at intervals of 7 to 15 days carrying a cargo of wet sludge containing an average of about 31 tons of dry solids. No odor nuisance has resulted from this method of sludge handling.

It is likely that such an arrangement as that used to concentrate crude sludge at New Haven is likewise applicable in separate sludge digestion plants to reduce the quantity of liquid input and consequent supernatant liquor displacement from the digestors.

Editor's Note.—The above article was prepared with the author's permission to extract a paper read by him before the North Carolina Sewage Works Association. The paper will later appear in full in the Sewage Works Journal.

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Interruption to Water Supplies

A classification of major interruptions to public water supplies in the United States and Canada, made by the Associated Factory Mutual Fire Insurance Companies, Boston, Mass., is presented by Charles W. Mowry in the *Journal* of the New England Water Works Association. A total of 405 major interruptions is included in the analysis, in every case of which an entire community, or a considerable portion of it, was without water for from 10 hours to several days.

Of these failures, 37, or 9 per cent, were at the source of supply—at either a reservoir or a standpipe. The causes are classified as follows:

Drought	20
Failure of dam	7
Anchor ice	4
Miscellaneous	6

It will be noted that 24 of the interruptions were caused by the elements.

Interruption of service at the pumping station accounted for 135, or 33 per cent, of the failures, which are distributed as follows:

Failure of electric power	45
High water and floods	20
Mechanical trouble at pump	20
Anchor and needle ice	20
Damage to station by fire	5
Damage to station by wind storm	4
Inadequate wells	5
Broken mains at pumps	5
Electric motor trouble	3
Obstruction in pump suction	3
Inadequate pumping capacity	2
New construction	3

Of these, 49 were caused by the elements.

Failures in the distribution system numbered 233, or more than half the total. Breaks in mains, numbering 183, resulted from such causes as failure of joints, explosion or blasting, split pipes, excess pressures, floods, collapse of bridges, electrolysis and frost. There were 10 valve failures.

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THE "WATER DOLLAR" OF ST. LOUIS, MO.—The following note from the annual report of the Water Commissioner of St. Louis, Mo., for the fiscal year ending April 13, 1931, shows the part of each dollar of the receipts which goes to each item of expense:

	Cents
Production and Purifying	38 8/10
Distribution, Meter and Inspection	11 3/10
Assessment, Billing and Collection	5 4/10
Commissioner's Office	2
Municipal Railway	0 8/10
Undistributed Expense	4 9/10
Sinking Fund and Interest	26 8/10
Operating Surplus	10
Total	$1.00

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

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THE USE OF CHARCOAL AND ACTIVATED CARBON IN WATER TREATMENT

Part 3: Characteristics of Activated Carbon

(*Continued from the November issue*)

THE characteristics of activated carbon in so far as it applied to the classification, manufacture, and activation of carbon was discussed in the previous issue. The material in this issue will deal with the chemistry of adsorption by active carbon.

Little Is Known of Some of the Chemical Characteristics of Activated Carbon.—At the present time the water chemist knows little of what to expect with activated carbon, except that most taste-producing compounds likely to be present in a water supply will be adsorbed by this material. Progress is being made, yet it will be several years before sufficient information is available for one to estimate accurately the cost of removing objectionable compounds from water with carbon. The extensive use of active carbon in some of the industries has resulted in much research work on this material, and some of the fundamentals of adsorption by carbon are understood. There may be divergence of opinion as to the exact mechanism of adsorption, though there is no doubt that it does take place.

The more we learn about the removal of dissolved compounds from solution by carbon, the more it is realized the problem is a very complicated one. In the first place little is known of the nature of the dissolved organic compounds likely to be present in the average surface or ground water. The very minute quantities of phenol which will produce objectionable tastes in water when chlorine is present is an indication that some compounds are objectionable when present in extremely small quantities. The chemist knows very little of the chemical composition of the compounds given off by algae to produce what we call an algae taste. There are indications that extremely minute quantities of such compounds may produce a disagreeable taste. It might be possible for hundreds of organic compounds to be present in water having less than two or three parts per million of dissolved organic matter present. Fortunately only a very few of the organic compounds are objectionable, yet the inoffensive compounds may be adsorbed by the carbon just as readily as the offensive compounds and they may reduce the adsorptive capacity of the carbon for the objectionable compounds.

There must be much research work to establish carbon in water treatment to where it will be regarded as an essential part of the treatment process in plants having water which is not up to the desired palatableness. It must be developed to the point where the cost and effectiveness can be predicted in advance for water of variable character. The chemist and the engineer must work together if rapid progress is made. The designing engineer must learn some of the main characteristics of such materials to be able to design plants where carbon can be used to the best advantage. Believing that some knowledge of the chemistry of what takes place is essential for a better understanding of the limitations of materials that accomplish their work by adsorption, the writer will go more into details of the chemistry of adsorption than is usually appropriate for a magazine dealing largely with engineering problems.

Nearly All Organic Compounds Adsorbed by Active Carbon.—Michaelis[12] states that there are only two substances known hitherto which are not adsorbed by charcoal—The sulfates of alkaline metals and glycocoll. Kolthoff[13] states that certain of the alkaloids are not adsorbed, or are adsorbed only very weakly. Miller and Bandemer[11], experimenting with ash-free active carbon, show that only the acid component of neutral salts is adsorbed, a hydrolysis taking place. It might be stated that practically all organic compounds are adsorbed by active carbon, but some are adsorbed to a much greater extent than others. Many of the inorganic substances are also adsorbed to a certain extent. So far as is known, all taste-producing compounds are adsorbed by active carbon, though some will be adsorbed to a much greater extent than others. If only the taste-producing compounds were adsorbed we would be fortunate, but this is not the case. Some of the inoffensive compounds are adsorbed just as readily as the offensive ones, and such compounds usually predominate in most waters. The carbon may become exhausted very quickly in some waters by the adsorption of inoffensive compounds and give very little service for the removal of the offensive compounds.

Various Conceptions of How Adsorption Takes Place.—The adsorption of non-electrolytes is very good evidence that adsorption by active carbon is not ionic. Michaelis[12] says that the adsorption faculty of a good charcoal is not only quantitatively but also qualitatively wholly different from any other adsorbing substance. It is very likely that the concomitant materials, such as

silica, aluminum, silicate, iron, etc., greatly influence the adsorbing qualities of commercial activated carbons. Certainly none of the commercial charcoals are pure carbon. Miller and his co-workers have shown that the inorganic bases of neutral salts are not adsorbed by ash-free sugar charcoal, yet most experiments on commercial active carbons show that both the positive and negative ions are adsorbed. Some have found by means of endosmosis that charcoal is electronegative in an alkaline solution and electropositive in an acid solution. Others have found that ash-free sugar charcoal is negative under all conditions.

Bruns and Frumkin[15] found that ash-free sugar charcoal behaves as a gas electrode when placed in solutions of electrolytes. The adsorption of acid or base by such charcoal results from the formation of an electric double layer at the carbon-liquid interface. The sign of the charge is determined by the nature of the gas content. Active carbon after exposure to the air adsorbs acid strongly but adsorbs no potassium hydroxide. The carbon cooled in H_2 gas adsorbs very much less acid than the air saturated material. The adsorption of benzoic acid is independent of the gas contained in the carbon.

Burstein and Frumkin[16] heated ash-free carbon to 1000°C. in hydrogen, and determined its adsorptive activity without exposing to air or oxygen. It adsorbed 0.066 milliequivalents of potassium hydroxide per gram of carbon from 0.01 normal KOH. No hydrochloric acid was adsorbed from the same strength solution. A gram of the same carbon when contaminated with air adsorbed 0.14 milliequivalents of hydrochloric acid from 0.01 normal solution, but no potassium hydroxide. After evacuating the carbon to 10^{-5}mm. at 1000 degrees for several hours, neither hydrochloric acid nor sodium hydroxide were adsorbed. Exposing the evacuated material to air it adsorbed 0.14 milliequivalents of hydrochloric acid from 0.01 normal solution. The work of Burstein and Frumkin indicates that the manner of activation, or at least the gases to which the carbon is exposed, has much to do with its characteristics. Some of the companies manufacturing activated carbon pass a certain amount of air through the material while it is heated to high temperature. The assumption is that it burns off materials that reduce the activity. It may be that the oxygen plays a part in the activation of the carbon.

The work of Miller and his co-workers on ash-free charcoal prepared from sugar is probably the most extensive experiments that have been conducted upon carbon. Even though the commercial carbons may behave somewhat different from the pure carbon, the experiments give the real characteristics of carbon. Bartell and Miller[17] show that the adsorption of methylene blue, a basic dye of the electrolytic type, is partially, if not entirely hydrolytic in nature. These authors[18] also demonstrate that the adsorption of acid dyes is accompanied by considerable hydrolysis and liberation of alkali which remains in solution. After investigating the adsorption of a number of acids, bases and salts they conclude that pure charcoal does not adsorb strong inorganic bases. The effect of adsorption of organic acids by the introduction of the hydroxyl group decreases the adsorption. Also the introduction of the amino group decreases the adsorption of organic acids, the extent depending upon the nature of the acid.

Miller[19] gives the results of hydrolytic adsorption of a number of organic and inorganic salts. There exists on the charcoal an amount of adsorbed acid equivalent to the alkali set free. With potassium chloride no potassium is adsorbed and the adsorption is entirely hydrolytic, for potassium hydoxide is formed to the same amount as the chloride adsorbed. With potassium benzoate a considerable amount of the salt as such is adsorbed in addition to the benzoic acid resulting from hydrolysis. Miller[20] studied the adsorption of hydrogen and hydroxyl ions, and concluded that the opinion held by many that hydrogen and hydroxyl irons are equally adsorbed was erroneous. Miller and Bandemer[21] found that adsorbed acids did not invert sucrose. "Since it is fairly certain that the inversion of sucrose by acids is due to the hydrogen ions it seems reasonable to conclude that the adsorbed acids on charcoal are in an undissociated state." They also state that the orientation of the acid molecule, if it took place, would undoubtedly be with the hydrogen ion away from the charcoal. This should favor the inversion of sucrose, which it does not do. Miller and Bandemer conclude that the adsorbed acid on the charcoal is held in the form of undissociated molecules or, possibly, as neutral atoms or groups on the adsorbing points of the charcoal.

Miller[22] states that all adsorbent charcoals when freed from inorganic and organic impurities and adsorbed acids have the same properties of adsorption from solution; that is, hydrolytic adsorption of salts, positive adsorption of acids and negative adsorption of inorganic bases. Miller believes that the supposed adsorption of bases by unpurified charcoals is due to reaction with acid impurities in the charcoal. Miller and Bandemer[24] investigated the adsorption from buffer solutions. Pure charcoal decreases the acidity of acid buffer solutions by adsorbing acids and increases the alkalinity of the less alkaline buffers by adsorbing the acid from the salts with the liberation of alkali. Pure charcoal does not increase the alkalinity of the highly alkaline buffers because it does not adsorb the inorganic hydroxides, but pure charcoal carrying adsorbed acids reduces the alkalinity of the solution by neutralization of some of the alkali. Unpurified blood charcoal reduces the alkalinity of the more alkaline buffers, but from the work of Miller and Bandemer they feel confident that it is due to the presence of impurities in the charcoal. Unpurified blood charcoal after ignition to drive off or decompose the acid impurities no longer reduces the alkalinity of the more alkaline buffers.

Parks and Bartlett[23] investigated the effect of inorganic salts on the adsorption of inorganic acids and bases. The hydrogen liberated by steam activation is strongly adsorbed and is difficult to remove. Sugar was charred and activated with steam for 30 minutes, and then heated in an atmosphere of nitrogen for one hour or more. Samples of this material produced about the same amount of adsorption of hydrochloric acid as sodium hydroxide. The presence of sodium chloride increases the amount of each adsorbed, which is not in agreement with the experiments of Miller. Coolidge[24] states that charcoal is a typical hydrophobic substance, and that it is difficultly wet with water. In aqueous solutions it is able to adsorb small concentrations of almost every substance undoubtedly with corresponding displacement of water, which seems to indicate that the direct attraction of carbon for water is exceptionally small.

Order of Adsorption of Various Compounds.—Michaelis[12] gives the following order of adsorption of cations: from lesser to increasing amounts, Na^+, K^+, and NH_4^+; Ca^{++}; Mg^{++}; Al^{+++}; H^+; and Alkaloids and basic organic dyes. Also the following order for anions: SO_4^-; Cl^-; Br^-; I^-; SCN^-; OH^-; and organic dyes, sulfosalicylic acid, and some of the other aromatic acids. Michaelis states that if we employ an electrolyte such as

HCl, it may be asserted from his investigation, that H^+ is better adsorbed than Cl^-. Since H^+ is placed almost at the end of the cation series and Cl^- is placed at the beginning of the anion series, H^+ may be considered as more adsorbable than Cl^-. He also states that since blood charcoal adsorbs both hydrochloric acid and sodium hydroxide, and since charcoal adsorbs hydrogen ions better than most all other cations, and hydroxyl ions better than most all other anions, the charge on the charcoal should be expected to be positive in hydrochloric acid and negative in sodium hydroxide, the isoelectric point being at a reaction approximately neutral. These expectations, he states, have been confirmed by cataphoresis experiments.

The Isoelectric Point of Charcoal.—Geyemant[25] found the isoelectric point for blood charcoal to be at pH of 3.5 with sulfuric acid and pH of 3.95 with hydrochloric acid by the electro-kinetic method. Umetsu[26] found by the same procedure the isoelectric point to be at pH of 3.0. Keeser[27] found values of 3.5 and 4.0 for the pH of two brands of blood charcoal, and for other charcoals values as high as 6.6 were obtained. Kroetz[28] found by adsorption from phosphate buffer solutions pH of 7.58 for blood charcoal. Bohn[29], also using phosphate buffer solutions, found values varying from 4.8 to 6.8. Miller and Bandemer[14] concluded from their experiments that the method of adsorption from buffer solutions cannot be used for the determination of the isoelectric point of charcoals.

Adsorption of Hydroxybenzenes and Other Aromatic Compounds.—Kolthoff and Van Der Goot[30] studied the adsorption from solutions of hydroxybenzenes and other aromatic compounds, and confirmed the results of Coolidge, who concluded that charcoal was a typical hydrophobic substance, and that it was difficultly wet by water. They state, however, that small amounts of hydrophylic impurities, especially silicon dioxide, exerts an enormous influence upon the adsorption of water especially at low pressures. For a good understanding of the mechanism of adsorption it is important to know whether the relation between the adsorption of strong electrolytes and non-electrolytes is dependent upon the properties of the charcoal. Kolthoff and Van Der Goot find some evidence that the adsorption of strong electrolytes is not dependent in the same way, upon the properties of the charcoal as the non-electrolytes. It was found that the tendency of the charcoal to saturate itself with the adsorbed substance grows with increasing number of polar groups.

Kolthoff and Van Der Goot give the millimols of several organic compounds adsorbed by one gram of active carbon (Carbo Merk) when the carbon is saturated with the substance.

It should be evident that activated carbon will not adsorb such large quantities of the compounds as given in the table and remove them almost completely from water. The saturation point is when no more of the compound will be adsorbed regardless of the concentration in the solution above the amount just necessary to saturate. The table shows that about 0.56 gram of phenol is adsorbed per gram of carbon at the saturation point. The amount adsorbed with lesser concentrations follows the Freundlich adsorption equation. If it is desired to have practically no phenol left in solution the amount that will be adsorbed is much less. The writer[31] found that one gram of Hydrodarco, Nuchar, or cocoanut char will adsorb about 0.005 gram of phenol and remove to the extent that less than 0.001 p.p.m. of phenol will be left in solution. This is only about 1/100 of the amount given in the table as adsorbed at saturation. For phenol, we are more concerned with the equilibrium between phenol and charcoal when not more than 0.001 to 0.005 p.p.m. of phenol is in solution than higher values. It requires only about this amount of phenol in the presence of chlorine to produce a disagreeable chlorophenol taste.

TABLE I

Substance	Millimols Adsorbed by One Gram of Carbon at Saturation
Aniline	7.0 Approximately
Phenol	6.0 Approximately
Resorcinol	3.7—4.0
Hydroquinol	3.9—4.4
Catechol	3.5—4.0
p. Nitrophenol	4.5—5.0
o. Nitrophenol	5.0
Pyrogallol	2.7
Phloroglucinol	2.5

Orientation of the Molecules Adsorbed by Carbon.—Kolthoff and Van Der Goot state that the polar groups of the aromatic compounds which they investigated could not be directed to the water, but must be oriented to the charcoal. "There is a possibility, that this orienting influence is directly exercised by the active charcoal particles, although it does not seem very plausable that the latter should have a larger preference for polar groups than water. However, it is quite possible that the orientation is caused by a secondary effect; namely, by the layer of adsorbed water on the charcoal. These molecules also are oriented, and it seems very probable, that they direct their polar side to the bulk of the solution."

If these authors are correct in their assumption of the manner in which certain aromatic compounds are oriented, and this is general for a large number of organic compounds, then it seems that one may predict to a certain extent the adsorption properties of the charcoal for all compounds of any of the organic groups by knowing the characteristics of one compound of the group. The most common polar groups in organic compcompounds are: —OH, —COOH, —CHO, —CN, —$CONH_2$, —SH, —NH_3, —$NHCH_3$, —NCS, —COR, —COOM, —COOR, —NO_2, —CH-CH_2, —C-CH, or groups which contain oxygen, nitrogen, sulfur, iodine, bromide, chlorine, double or triple bonds. Water is highly polar. There is no direct evidence that all compounds with the above polar groups will be oriented with their polar groups to the charcoal. In fact, Kolthoff and Van Der Goot state that the water molecules very likely orients with the polar directed to the bulk of the solution.

Table II shows the probable manner in which molecules are oriented at the carbon surface. The carbon atoms at the right of the compounds are supposed to represent solid carbon with only the left C exposed on the surface.

Adsorption Increases with Increasing Carbon Atoms.—Landt and Bhargava[32] state that fatty acids are adsorbed at an increasing rate directly as the number of carbon atoms is increased. Acetic acid is adsorbed to a greater extent than formic acid, and proprionic acid to a greater extent than acetic. Freundlich[33] also shows that this is the case for fatty acids, and states that it has been found to be the case with urethane compounds. According to Gibbs' Adsorption Law the quantity of a compound adsorbed increases in proportion as the surface tension of the solution becomes diminished by increasing concentration. This means that substances which lower the surface tension of water most rapidly

TABLE II — PROBABLE MANNER IN WHICH MOLECULES ARE ORIENTED AT THE CARBON SURFACE

Compound	Compound Adsorbed	Carbon Solid
Benzoic acid	$C_6H_5.COOH$	C C C C
Salicylic acid	$HO.C_6H_4.COOH$	C C C C
o-Aminobenzoic acid	$NH_2.C_6H_4.COOH$	C C C C
Succinic acid	$CH_2.COOH$ / $CH_2.COOH$	C C C C / C C C C
Malic acid	$CHOH.COOH$ / $CH_2.COOH$	C C C C / C C C C
Tartaric acid	$CHOH.COOH$ / $CHOH.COOH$	C C C C / C C C C
Aminosuccinic acid	$CH_2.COOH$ / $CHNH_2.COOH$	C C C C / C C C C
Formic acid	$H.COOH$	C C C C
Acetic acid	$CH_3.COOH$	C C C C
Propionic acid	$CH_3.(CH_2)_2.COOH$	C C C C
Butyric acid	$CH_3(CH_2)_2.COOH$	C C C C
Lactic acid	$CH_3.CH(OH).COOH$	C C C C
Glycocoll	$NH_2.CH_2.COOH$	C C C C
Phenol	C_6H_5OH	C C C C
Aniline	$C_6H_5.NH_2$	C C C C
o-Cresol	$CH_3.C_6H_4.OH$	C C C C
Resorcinol (1, 3)	C_6H_4 (OH, OH)	C C C C / C C C C
Hydroquinol (1, 4)	C_6H_4 (OH, OH)	C C C C / C C C C
Pyrogallol	C_6H_3 (OH, OH, OH)	C C C C / C C C C / C C C C
p-Nitrophenol	$NO_2CC_6H_4.OH$	C C C C
Gallic acid (3, 4, 5, 1)	$C_6H_2.(OH)_3.COOH$	C C C C
Pyridine	C_5H_5N	C C C C
Picric acid	$(NO_2)_3C_6H_2.OH$	C C C C
Coniine (adsorbed slightly)	$C_5H_{10}N.C_2H_7$	C C C C
Methane (non-polar, not highly adsorbed)	CH_4	C C C C
Ethane (non-polar, adsorbed more than CH_4)	CH_3CH_3	C C C C
Propane (non-polar, Ads. more than C_2H_6)	$CH_3CH_2CH_3$	C C C C
Water	$OH.H$	C C C C
Hydrochloric acid	$Cl.H$ or $H.Cl$	C C C C / C C C C
Potassium chloride (KOH not adsorbed)	$Cl.H$	C C C C
Sodium hydroxide (not adsorbed)		C C C C

as the concentration increases will be adsorbed to the greatest extent. Kolthoff[13] says that the adsorption of acids is molecular and follows the order of depression of the surface tension at the water-air interface.

The increased adsorption with increasing carbon atoms, or decrease in surface tension, is believed to be fairly general for all the groups of organic compounds, though there are some deviations. Methyl alcohol is adsorbed more highly than ethyl alcohol. The saturated hydrocarbons follow the general rule, in that propans is adsorbed more highly than ethane, and ethane more highly than methane. If the polar groups are directed to the carbon surface, it seems likely that compounds containing two polar groups will be adsorbed in lesser quantity than compounds with one polar group, and compounds with three polar groups will be adsorbed in lesser quantity than compounds with two polar groups. Kolthoff and Van Der Goot[39] show that this is the case when trihydric phenols are compared with dihydric phenols, or the dihydric phenols compared with ordinary phenol or cresol.

There is not much relation between the various groups of organic compounds and the amount adsorbed by active carbon. Benzoic acid is adsorbed to a much greater extent then benzene, but to a lesser extent than phenol. Chloroform is adsorbed more highly than the aliphatic acids. Bartell and Miller[18], experimenting with ash-free sugar charcoal, show that the inorganic hydroxides are not adsorbed, and that the inorganic acids are not as highly adsorbed as the organic acids. Table III shows the amount of acid adsorbed by 0.25 gram of ash-free sugar charcoal as given by these authors.

Examination of the figures determined by Bartell and Miller and given in Table III shows the effect on adsorption produced by the introduction of hydroxyl and amino groups into the acids. The introduction of these groups decreased the adsorption, the hydroxyl group as a rule producing a smaller effect than the amino group. The table shows that salicylic acid is adsorbed to a lesser extent than benzoic acid, malic and tartaric acids are adsorbed to a less extent than succinic acid, and lactic acid to a less extent than propionic acid. These authors show that the effect of the amino group is still more striking. o-Aminobenzoic acid is adsorbed slightly less than either benzoic or salicylic acids. Aminosuccinic acid is adsorbed very much less than succinic acid, malic acid, or tartaric acid; and glycocoll is not adsorbed at all.

It is seen from the chemical literatures that there is sufficient agreement among the various chemists who have investigated active carbon to define some of its main characteristics.

All Taste-Producing Compounds Believed to Be Adsorbed.—Even though the organic compounds are very numerous, the literature on adsorption by active carbon indicates very conclusively that nearly all organic compounds will be adsorbed. With the exception of the chlorinous tastes, nearly all taste-producing compounds likely to be in potable water are organic compounds of some kind. Of the compounds which we have some knowledge of their being responsible for objectionable tastes in water, all are highly adsorbed by active carbon. However, we do not know the nature of most of the compounds producing objectionable tastes. There

TABLE III—ADSORPTION OF ACIDS BY CHARCOAL (From Bartell and Miller)

Group	Compound	Formula	Amount Adsorbed Expressed in CC. of 0.01 N. Solution
Aromatic acids	Benzoic	$C_6H_5.COOH$	75.80
	Salicylic	$HO.C_6H_4.COOH$	73.76
	o-Aminobenzoic	$NH_2.C_6H_4.COOH$	67.00
Dicarboxlic acids	Succinic	$(CH_2.COOH)_2$	48.00
	Malic	$CHOH.COOH.CH_2.COOH$	35.88
	Tartaric	$CHOH.COOH.CHOH.COOH$	31.76
	Aminosuccinic	$HOOC.CH_3.CHNH_2.COOH$	8.78
Aliphatic acids	Formic	$H.COOH$	15.70
	Acetic	$CH_3.COOH$	16.44
	Propionic	$CH_3.CH_2.COOH$	24.36
	Butyric	$CH_3.(CH_2)_2.COOH$	35.52
	Lactic	$CH_3.CH(OH).COOH$	17.86
	Chycocoll	$NH_2.CH_2.COOH$	0.0

is very good evidence that the following tastes will be removed by active carbon:

Aldehol	Flat	Pig pen
Algae	Gasoline	Peaty
Aromatic	Grassy	Ripe cucumber
Chlorine	Humous	Rivery
Chlorophenol	Medicinal	Sewage
Creosote	Marshy	Stagnant
Decaying vegetation	Moldy	Swampy
Decomposition	Musty	Sweetish
Earthy	Melting ice	Tarry
Fishy	Oily	Woody

As to the numer of compounds that go to make up these various tastes, there is no information. Perhaps hundreds of compounds are responsible.

No Means of Detecting Most Organic Compounds.—At the present time there is no means of detecting many of the organic compounds that occur in water, for they usually occur in such small quantities. Some water works laboratories make tests on the water for oxygen consumed, but this tells very little of the nature of the compounds present. Tests for ammonia may be an indication that some of the amino compounds are present, but this also gives very little information as to the exact nature of the compounds containing ammonia. So far as is known none of the organic compounds containing ammonia are likely to be present in potable water to the extent that they will give taste to the water. Water having twice the amount of ammonia as some other water may be just as palatable.

The Action of Chlorine on Carbon.—At first, chemists were of the opinion that carbon absorbed chlorine from solution the same as it does other materials, but it is now known that the chlorine is converted to hydrochloric acid, accompanied by an oxidation of the carbon. The mechanism may first be one of adsorption, but the oxygen of the hypochlorous acid quickly unites with the carbon. The addition of chlorine to water forms hypochlorous and hydrochloric acids according to the following reaction:

$$Cl_2 + H_2O \rightarrow OHCl + HCl$$

With small amounts of chlorine the reaction may go to completion, but with larger amounts there may exist chlorine gas dissolved in water with only a small part of it reacting with water. Bohart and Adams[34], and Gibbs[35] show that the reaction of chlorine in the presence of water and charcoal is:

$$2Cl_2 + 2H_2O + C \rightarrow 4HCl + CO_2$$

The oxygen unites with the carbon to Form CO_2 instead of being liberated as a gas. These authors were searching for a method of converting chlorine gas to hydrochloric acid. Gibbs states that the reaction when carbon is used was satisfactory in that all the chlorine was converted to hydrochloric acid, but very disappointing in that the oxygen does not appear as such but unites with the carbon. The conversion of chlorine to hydrochloric acid with carbon at a high temperature was patented by Lorenz (British Patent No. 25,073) in 1894. Chlorine mixed with steam was passed over coke, charcoal, or anthracite coal heated to a low red heat. Bohart and Adams show that there is an appreciable conversion of the chlorine to hydrochloric acid with the production of CO_2 at 0 degrees C., and that the rate of reaction increases as the temperature increases.

Kolthoff[36] investigated the decomposition of bromine by charcoal in an aqueous solution, and concluded that bromine was rapidly decomposed when in contact with carbon according to the following reaction:

$$2Br_2 + 2H_2O \rightarrow 2HBr + O_2$$

Work in the writer's laboratory shows that most of the gas given off at a temperature of about 75 to 80°C. is carbon dioxide, indicating that the reaction at this temperature is the same as with chlorine. Very little gas was given off at 25 degrees, and there was no evidence that oxygen was formed to any material extent. Frank and F. Pullen Candy obtained a patent (British Patent No. 10,705) in 1916 on the use of brown coal or lignite for dechlorinating water. The patent states that it is more effective than carbonized lignite, which they had been using previously.

Testing the Adsorptive Capacity of Carbon.—The molasses test is frequently used for determining the decolorizing properties of carbons, especially those used in the sugar industry. Strachan[37] gives the following procedure for making the molasses test. The molasses solution is obtained by diluting approximately 20 grams of beet molasses to 1,000 cc. with distilled water. 10 cc. of phosphate buffer solution (made by dissolving 15 grams of sodium hydroxide in about 500 cc. distilled water to which 130 cc. of phosphoric acid, 25 per cent strength, is added: make up to one liter) is added and the solution is shaken for some time. The exact quantity of beet molasses depends upon the original color of the molasses. Sufficient is taken to bring the color of the filtrate to 0.9—1.0 stammer when the solution has been treated with 1,000 milligrams of standard carbon. Boil 200 cc. of the molasses solution for a few minutes in a 500-cc. erlenmeyer flask with 1,000 milligrams of the carbon to be tested. The liquid is then filtered through paper, being passed a second time through the same filter paper. A part of the second filtrate is used for determining the decolorization obtained.

This is not a quantitative test, and merely compares the decolorizing properties of the material to be tested with some carbon which is adopted for the standard. It may give a fairly good comparison of the decolorizing properties of carbons tested, yet the problem of decolorizing sugar and the removal of taste-producing compounds from water are so different it is believed that some other test might be better. The chloropicrin test is frequently used for comparing the gas adsorptive qualities of active carbon, though it does not seem that this test would give a satisfactory indication of the adsorptive capacity of carbon for water works use.

The writer uses phenol for testing the adsorptive capacity of carbon. There are several reasons for using this material. It is a compound that occasionally causes objectionable tastes in water, and is a compound that is highly adsorbed. It also is a compound in which very minute quantities can be determined. It is possible to determine phenol when it is present in water only to the extent of 0.001 part per million. The fact that some, if not many of the tastes occurring in water are produced by compounds which occur in quantities less than 0.01 part per million, the desirability of using a compound for testing that may be determined when present in extremely minute quantities is evident. Gibbs[38] worked out a test for phenol in which 2, 6-dibromoquinonechloroimide is used to produce indophenol. The writer[39] gave a quantitative method for using the Gibbs test. Theriault[40] has made certain modifications of the test, which seems to be more convenient for determining extremely minute quantities of phenol.

The procedure for testing samples of carbon used by the writer is to add various amounts of phenol to one-liter samples of water, then add 1-gram samples of the carbon. With a machine that has six stirrers, six samples with varying amounts of phenol may be stirred at the same time. The carbon is pulverized to pass a 200-

mesh sieve before adding to the solution. The mixture is usually stirred for 4 hours, filtered through paper, and the solutions tested for the amount of phenol remaining in solution by the method to which reference has been made. The lowest amount of phenol used should be such that less than 0.001 p.p.m. of phenol is left in solution, and the highest amount used should be such that all the phenol is not removed by the carbon.

A good grade of commercial activated carbon should adsorb at 20° to 25°C. about 5 milligrams of phenol per gram of carbon, and leave less than 0.005 milligram in the one liter of solution. It should adsorb 15 milligrams per gram of carbon and leave only 0.200 milligrams, or 0.200 p.p.m. of phenol in the one liter of solution.

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The Value of Pitometer Surveys, Metering and Meter Testing

Data obtained from pitometer surveys of seven cities in Wisconsin reveals the fact that the water which could be accounted for represented an average of 89 per cent of that actually delivered into the distribution system at the time these surveys were made. The per cent unaccounted for could be traced on the average to the following:

	Per cent
Incorrectly registering meters	4.5
Leaky services	5.2
Leakage from mains	1.3

In a paper recently read before the Wisconsin Section of the American Water Works Association, P. J. Hurtgen, Director Public Works, Kenosha, Wis., brought out the fact that surveys at Kenosha had disclosed a 14 per cent discrepancy between pumped water and water paid for by consumers; and such losses had been found to be due primarily to errors in the registration by large meters.

Testing practically all of the large meters in one district at Kenosha and repairing the faulty ones resulted in an increased income of $2,000 for water billing from one district during the year.

Having tested several makes of household size meters at Kenosha it has been concluded that small household fixture leakages will not be registered. In order therefore to stop such losses, this must be accomplished by appraisal of the consumers as to what leaks of various sizes amount to in wasted water.

Concerning pitometer surveys—it is not the average conditions such as was revealed in the Wisconsin surveys that is of primary interest, but rather the location of the most expensive "leaks" which can usually be inexpensively corrected as illustrated by the Kenosha experiences. After introducing metering it would seem to pay to check up at intervals the accuracy of the larger meters in particular.

It may frequently be found from pitometer surveys that pump efficiencies have fallen to an extent that metering errors plus leakage and the erroneous pumpage records so nearly coincide as to mislead the water works Superintendent into belief that there are no serious water losses along the system when in reality there is.

The business end of the water supply would seem to demand "Checking and double checking"—the first through metering and the equally important "double checking" by making an occasional pitometer survey of the system.

The State Capital at Richmond, Va.

VIRGINIA WATER AND SEWAGE WORKS ASSOCIATION

THE third annual meeting of the Virginia Water and Sewage Works Association held at Lynchburg, Va., on Nov. 16th and 17th, was without question one of the most interesting sectional meetings ever attended by this writer. The program did credit to those responsible for the arrangements and the entertainment supplied by the City of Lynchburg was truly an example of real Southern hospitality and the progressive spirit of that city.

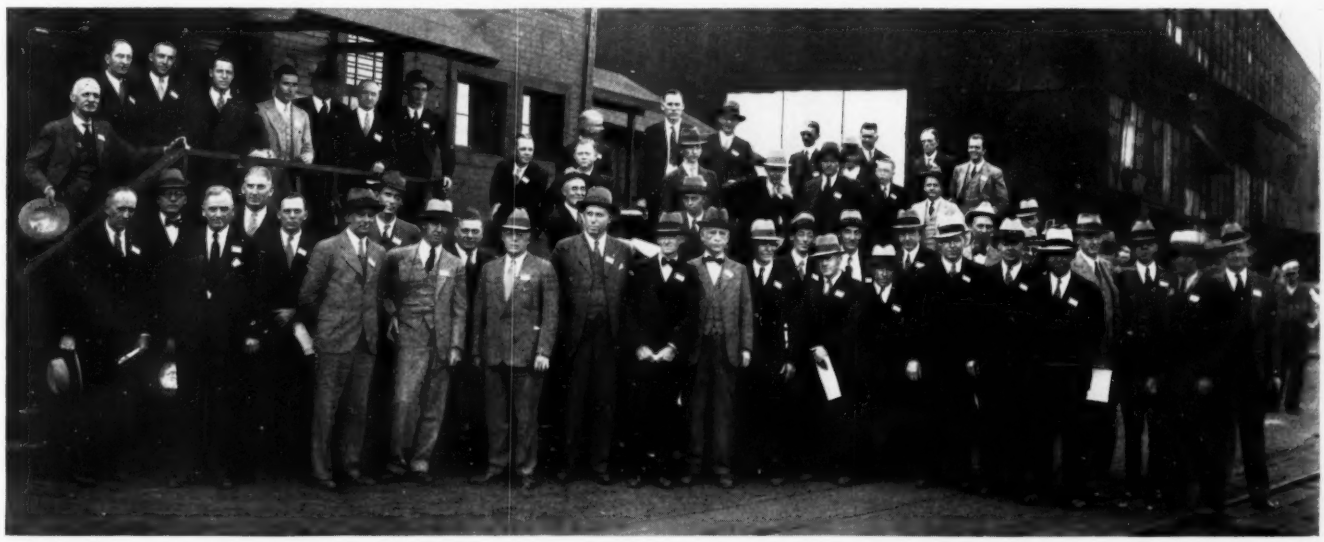
The meeting was ably preside dover by Richard F. Wagner, President of the Association and Director of Water Supply and Safety at Lynchburg. Mr. H. W. Snidow, Secretary and Assistant Engineer of the Virginia State Department of Health, was jointly responsible with the President for the highly interesting and well prepared technical papers.

A trip of inspection was made during the meeting to the two Cast Iron Pipe and fittings foundries in Lynchburg—The Glamorgan Pipe and Foundry Company and the Lynchburg Foundry Company.

Following this the Lynchburg Filtration Plant was visited and an item of interest there was the new "Aero-Mix" installation serving the dual function of raw water aeration and a chemical mixing device.

On the evening of the first day those attending the meeting were guests of the City of Lynchburg at a banquet which was followed by songs and spirituals tendered by a double male quartet of Negro voices and thereafter a most pleasing program of dancing and vocal renditions by a few of the belles of Lynchburg.

To indicate that the program represented an ambitious undertaking, a technical session followed the banquet. It was somewhat of a surprise to this writer to see the size of the attendance and the attention of the audience, but to have heard the interesting talk made by **William E. Carson,** to Virginians on, **"Conserving** and **Developing Virginia,"** was easy to understand why the evening session proved the success that it did. Mr. Carson, who, by the way, is chairman of the State Conservation and Development Commission, told his audience that Virginia has within its borders to merit the interest of the world. He also reviewed the progress taking place in developing the natural assets possessed by the "Old Dominion." The development of National Parks and State Parks, of scenic highways already constructed or being built, the work in water power development, the beautification of the state, and the preservation and restoration of historical landmarks which was all under way was a revelation even to a native Virginian. All of this, Mr. Carson said, was obliged to increase the number of tourists entering Virginia and that he considered the drinking water of the state as of paramount importance in this development, and that Virginia might well afford to assure its visitors that all of the public water supplies were safe and properly looked after. He thought that the "Safe Water" signs posted on Virginia highways by the State Department of Health would do much to show these visitors that they might use the water without fear of contracting disease. Mr. Carson,



A Group from the Virginia Water and Sewage Works Association Meeting Visit the Lynchburg Foundry Co.'s Pipe Works

having disposed of the business of "selling Virginia to Virginians," closed his talk with a number of highly entertaining accounts of how he had "sold" Virginia to the President of the United States and other important men in the nation's affairs. This writer would say, that if Virginia were paying Mr. Carson in commissions on "sales" the "Mother of States" would possibly have to buy back from him the Natural Bridge and probably Jamestown Island also.

Professor Lauren B. Hitchcock of the Department of Chemical Engineering at the University of Virginia, told his audience of **"Virginia's Chemical Industry of Today"** in which he emphasized the very important

Richard Messer, Chief Engineer, State Department of Health of Virginia

Richard F. Wagner, President, Virginia Water and Sewage Works Association

H. W. Snidow, Secretary, Virginia Water and Sewage Works Association

place which water supply and streams played in the rapidly growing chemical industry within the state. The rayon industry which had grown so rapidly in Virginia required the highest purity of water. Virginia had the largest nitrogen fixation plant in the world, located on the James River, and that its water purification plant was one of the most important parts of that great factory. That the chemical industry in Virginia gave employment to 181,000 people and had a payroll of about $151,000,000 per year and without water supply of the proper quantity and quality this would be impossible. That Virginia produced the greatest diversity of chemical products of any southern state. That high-grade paper production was one of its chief assets, also. That the Viscose Company's plant at Roanoke, Va., had grown from a small beginning in 1917 to the largest plant of its kind in the world. Surprisingly enough the Muscel Shoals development is completed would have been capable of producing but 40 tons of nitrogen per year, whereas the plant at Hopewell, Va., would produce 120 tons per year. Professor Hitchcock then touched on stream pollution by the industry, stating that this matter was receiving increased attention by the industry and that it was no recognized that Virginia streams had been relieved of much of their waste burdens within the past two years and that an equitable use of the waters of Virginia streams was of paramount importance to the well being of Virginia's chemical industry.

L. H. Enslow, editor of these pages, spoke on **"Developments of Interest in Water Supply and Sewage Disposal"** and concluded with the observation that more and more it was becoming apparent that the water works men must interest themselves in sewage treatment for it was merely a matter of where cities were located in respect to one another on a stream as to whether it was sewage first and water afterwards or vice-versa. In other words what frequently was one city's sewage or industrial waste was the next city's water supply. After all it became a matter of dealing in concentrations of impurities as to whether one was operating a sewage treatment plant or a water purification plant and that basically the problems of each operations were hydraulic and bio-chemical and therefore water works men were logically fitted to operate and manage sewerage systems and treatment works. In addition, the supervision of both of these utilities instead of one alone, would yield increased returns to the man equipped to take charge of both.

Technical Sessions

In the technical sessions discussions bearing on the practical aspects, taste and odor removal, covering of reservoirs, the value and importance of effective mixing of chemicals and a noval development in this direction at the Richmond, Va., filtration plant were the principal topics of interest covered in water purification and treatment.

A very interesting and practical paper was presented by **E. H. Ruehl,** city manager of Bluefield, Va., describing **"A Program and Details of Metering"** that city. A discussion of value followed in which service pipe materials and methods of installation was covered also. Papers of this nature are usually conspicuous by their absence from sectional meetings and the lengthy discussion which followed was indicative of the need of more such papers like that of Mr. Ruehl. Another very practical talk was that given by **H. E. Beckwith,** of The Pitometer Company, on **"Pump Tests and Efficiency Evaluation."**

Sewage treatment was covered in a **Round Table** led by **Lee H. Williamson** of Richmond, Va.

Papers on sewage treatment covered descriptions of treatment plants and operation results from plants at Hollins College, Blacksburg, and Charlottesville, Va. In the paper by **Stirling Wiliamson,** city engineer

of Charlottesville, Va., some very interesting **"Experiences in Starting a New Sewage Treatment Plant"** were recounted.

The meeting in 1932 will be held at Staunton, Va., the home of *W. F. Day,* the newly elected president of the association and city manager of Staunton. Other officers elected: Vice-Chairman, E. F. Dugger, Newport News, Va.; Vice-Chairman, E. H. Ruehl, Bluefield, Va.; Secretary, H. W. Snidow, Richmond, Va.

Editor's Note.—Lack of space prevents the inclusion in this issue of condensed contents of the papers read and the ensuing discussion. Our next issue will carry this material. Papers presented at the Virginia meeting will appear in the January and subsequent issues of WATER WORKS AND SEWERAGE.

LIST OF REGISTRANTS

B. L. Strother, Filter Plant Supervisor, Ampthill, Richmond, Va.
H. B. Shawen, Mayor, Altavista, Va.
R. C. Tippett, Supt. Water Works, Altavista, Vt.
E. A. Smith, Councilman, Altavista, Va.
Edward H. Ruehl, City Manager, Bluefield, Va.
E. B. Porter, Engineer, Catawba Sanatorium.
F. L. Watson, Mayor, Charlottesville, Va.
H. A. Yancey, City Manager, Charlottesville, Va.
Stirling Williamson, City Engineer, Charlottesville, Va.
C. B. Neblett, Asst. Health Officer, Charlottesville, Va.
B. L. Haymaker, Mayor, Christiansburg, Va.
Howard A. Johnson, Supt. Filtration, Danville, Va.
R. F. Whitaker, Supt. Water and Streets, Emporia, Va.
R. W. Catlin, Town Manager, Farmville, Va.
B. J. Harvey, Filter Plant Engineer, Farmville, Va.
J. W. Simmons, Sanitation Officer, Farmville, Va.
C. H. Dougherty, Supt. Water Works, Franklin, Va.
G. W. Wesson, Mayor, Lawrenceville, Va.
H. W. Hayes, Supt. Water Works, Lawrenceville, Va.
J. Tanner Kinnier, Mayor, Lynchburg, Va.
R. W. B. Hart, City Manager, Lynchburg, Va.
Richard F. Wagner, Dir. Public Safety & Water, Lynchburg, Va.
A. L. Hunt, Supt. City Filter Plant, Lynchburg, Va.
R. D. Wright, Asst. Engr. Dept. of Water, Lynchburg, Va.
Allan Price, Jr.,City Water Dept., Lynchburg, Va.
M. D. Knight, Jr., Dir. Public Works, Lynchburg Va.
Harry R. Brown, Councilman, Lynchburg, Va.
C. L. DeMott, Councilman, Lynchburg, Va.
John Victor, Councilman, Lynchburg, Va.
Thos. R. Turner, Councilman, Lynchburg, Va.
B. S. Parrish, Supt. Public Works, Martinsville, Va.
J. W. Booker, Jr., Councilman, Martinsville, Va.
E. F. Dugger, General Manager, Newport News, Va.
E. H. Herbert, Chief, Engr., Division of Water, Norfolk, Va.
R. W. Fitzgerald, Chief Chemist, Division of Water, Norfolk, Va.
Chas. W. Davis, Jr., Supt. Water Works, Petersburg, Va.
H. W. Rankin, City Manager, Radford, Va.
Marsden C. Smith, Engr. Water and Electricity, Richmond, Va.
F. O. Baldwin, Supt. Filtration, Richmond, Va.
C. F. Bingham, Asst. Supt. Filtration, Richmond, Va.
G. A. Robertson, Dept. Public Utilities, Richmond, Va.
D. R. Taylor, Supt. Water, Roanoke, Va.
James M. Caird, Sanitary Engineer, Roanoke, Va.
Jos. P. Milliken, Chemist and Bacteriologist, Troy, N. Y.
Roy P. Bishop, City Manager, Salem, Va.
Chas. A. Johnson, Supt. Water Works, Salem, Va.
W. S. Russell, Supt. Filtration, Salem, Va.
J. E. Carper, Water Dept., Salem, Va.
E. B. Wood, Chief Engineer, Riverside & Dan River Cotton Mills Co., Schoolfield, Va.
E. G. Yates, Operator, Riverside & Dan River Cotton Mills Co., Schoolfield, Va.
H. C. Jones, Operator, Riverside & Dan River Cotton Mills Co., Schoolfield, Va.
R. L. Warren, Supt. Water Works, South Boston, Va.
W. F. Day, City Manager, Staunton, Va.
Hugh B. Rice, Supt. Water Works, Staunton, Va.
J. R. Abbitt, Supt. Grounds & Bldgs., Sweet Briar, Va.
A. L. Meisel, City Engineer, Williamsburg, Va.
P. P. Pilcher, City Manager, Winchester, Va.
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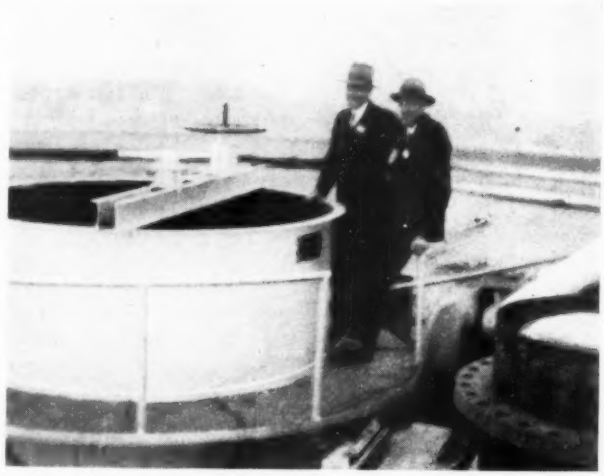
Fred E. Stuart, Industrial Chemical Sales Co., New York, N. Y.

H. P. Boykin, Assoc. Prof. Civil Engineering, Virginia Military Institute, Lexington, Va.
E. W. Saunders, Prof. Civil Engineering, University of Virginia, University, Va.
L. B. Hitchcock, Assoc. Prof. Chemical Engineering, University of Virginia, University, Va.
John E. Blarm, Engineering Dept., University of Virginia, University, Va.
R. E. Lee Gildea, Student Engineer, University of Virginia, University, Va.
J. W. Beverage, Student Engineer, University of Virginia, University, Va.
John Hitchcock, Student Engineer, University of Virginia, University, Va.
Samuel C. Johnson, Supt. Big Bethel Filtration Plant, U. S. Government, Hampton, Va.
Jas. W. Engle, Chemical Engineer, U. S. Government, U. S. War Dept., Washington, D. C.
W. W. Berry, Supt. Fort Humphreys Filter Plant, U. S. Government, Accotink, Va.
Vincent B. Lamoureux, Asst. San. Engr., U. S. P. H. S., U. S. Government, Washington, D. C.
H. M. Sears, Forest Supervisor, Natural Bridge National Forest, U. S. Government, Lynchburg, Va.
R. C. Bardwell, Supt. Water Supply, Chesapeake & Ohio Ry. Co., Richmond, Va.
R. M. Stimmel, Chief Chemist, Chesapeake & Ohio Ry. Co., Huntington, Va.
P. V. Littlejohn, Chemist, Norfolk & Western Ry. Co., Roanoke, Va.
Morton L. Wallerstein, Executive Secretary, League of Virginia Municipalities, Richmond, Va.
Philip Bingen, Bingen-Niple Engr., 568 Broad St., Columbus, O.
E. J. F. Wilson, Wiley & Wilson, Engr., Lynchburg, Va.
W. Martin Johnson, Wiley & Wilson, Engrs., Lynchburg, Va.
Elmer E. Bernard Consulting Engineer, Lynchburg, Va.
J. O. Magruder, DeMott & Magruder, Engrs., Lynchburg, Va.
Nathan M. Palmer, Staff of Advance, Lynchburg, Va.
Edgar J. Buttenheim, President, American City Magazine, New York City.
L. H. Enslow, Editor, WATER WORKS AND SEWERAGE, New York City.
Lee H. Williamson, Seville & Williamson, Inc., Richmond, Va.
P. H. Johnson, Jr., Graduate Engineer, South Boston, Va.
F. C. Taylor, Pittsburgh Equitable Meter Co., Asheville, N. C.
H. B. Spaid, Pomona Pump Co., Atlanta, Ga.
E. J. Canton, Badger Meter Co., Baltimore, Md.
E. W. Bixby, Columbia Iron Works, Chattanooga, Tenn.

A Real "HE" C. I. Special; Molded for Chicago Sewage Works by The Glamorgan Pipe and Foundry Co., Lynchburg, Va.

R. E. Kitchner, Mueller Company, Decatur, Ill.
H. E. Beckwith, Pitometer Co., Harrisburg, Pa.
I. M. Hodges, Leaksville, N. C.
E. F. Parker, Coca Cola Bottling Co., Leaksville, N. C.
Howard J. Pardee, Pres., Pardee Engineering Co., Long Island City, N. Y.
J. J. Schmidt, Vogt Bros. Mfg. Co., Louisville, Ky.
Ernest L. Vogt, Vogt Bros. Mfg. Co., Louisville, Ky.



The Vogt "Acr-O-Mix," Lynchburg, Va., Filtration Plant

Herman Anderson, Louisville, Ky.
Jack Dabney, Glamorgan Pipe & Foundry Co., Lynchburg, Va.
W. R. Odor, Lynchburg Foundry Co., Lynchburg, Va.
W. F. Murphy, Lynchburg Foundry Co., Lynchburg, Va.
G. R. Johnson, V. P., Lynchburg Foundry Co., Lynchburg, Va.
John T. Woodson, Sales Mgr., Lynchburg Foundry Co., Lynchburg, Va.
R. H. Hogan, Noland Company, Lynchburg, Va.
G. L. Wirtz, Atlas Mineral Products Co., Mertztown, Pa.
Robert B. Mowry, Wallace & Tiernan, Newark, N. J.
Jas. E. Williamson, Jr., Rensselaer Valve Co., New York City.
E. V. Young, Central Foundry Co., New York City.
M. J. Siebert, Neptune Meter Co., New York City.
F. E. Stuart, Research Engineer, Ind. Chem. Sales Co., New York City.
F. H. Dawson, Darling Valve Mfg. Co., Philadelphia, Pa.
Alan A. Wood, District Manager, Builders Foundry, Philadelphia, Pa.
H. F. Harveson, Assistant Manager, Simplex Valve & Meter Co., Philadelphia, Pa.
B. D. Hubley, Hersey Mfg. Co., Philadelphia, Pa.
L. P. Madden, Ludlow Valve Mfg. Co., Pittsburgh, Pa.
A. B. Sanderson, Jr., Pittsburgh Des Moines Steel Co., Pittsburgh, Pa.
Garland Sydnor, Sydnor Pump & Well Co., Richmond Va.
Chas. F. Cole, President, Va. Machinery & Well Co., Richmond, Va.
F. D. Dimmick, R. D. Woody Co., Richmond, Va.
Wm. Clift, Phipps & Bird, Richmond, Va.
W. Y. Bicklehaupt, Bicklehaupt, Inc., Richmond, Va.
I. A. Bicklehaupt, Bicklehaupt, Inc., Richmond, Va.
H. B. Hawkins, Hawkins-Hamilton, Inc., Richmond, Va.
Chas. R. Elam, Virginia Engineering Co., Richmond, Va.
J. M. Masterson, Wallace & Tiernan, Roanoke, Va.
Richard B. Ford, Ford Meter Box Co., Wabash, Ind.

▼

Committee to Study Stream Pollution

Owing to the increasing number of complaints, due chiefly to the discharge of wastes from canning factories and creameries, the State Department of Health of New York and the New York State Conservation Department have taken steps toward cooperative action in the stream pollution problem. A committee has been appointed to make a study of stream pollution control in other states with a view to securing any legislation that may be necessary. The members of this committee are: M. K. Bracket, Chief Inspector, Emmeline Moore, Biologist, and Russell Suter, Executive Engineer, State Water Power and Control Commission, all of the Conservation Department; C. A. Holmquist and A. F. Dappert, Director and Assistant Sanitarian, respectively, of the Division of Sanitation, New York State Department of Health.

SYMPOSIUM OF PRACTICE

THE KIND AND SIZE OF PIPE FOR WATER SERVICES

San Francisco, Calif.

The question as to the kind and size of pipe to be used for water services is one which depends so much upon varying conditions that in my opinion it is impossible to give a set answer.

In San Francisco, until the first part of 1909, all services were of lead pipe. Beginning in 1909 we discarded the lead service substituting the ordinary galvanized steel pipe. In 1927 we made an exhaustive study of all the leaks occurring in our services and found that while about 70 per cent of our services were laid in light sandy soil and 30 per cent in heavy soil, the services in the heavy soil accounted for over 70 per cent of the leaks. Since that time whenever the soil is too heavy to permit of our driving the pipe under the pavement we use copper tubing. Where the soil is light enough to permit driving we still use the galvanized iron.

We also found through that examination that a large number of our leaks came in the threads, just outside the fittings, which was logical as these threads had no coating and were of thinner metal. Since that time we have been coating these exposed threads heavily with red lead before covering the pipe. I believe this practice is good for San Francisco—it may not be good for any other place.

The size of services installed is one which is still very much a matter of cut and try. I hope that some day experiments may be run on a large enough scale to reasonably well determine the size of services and particularly the size of house piping necessary to supply the different combinations of families that may be grouped in one building, which ranges all the way from the single family house to the apartment housing many families.

Under normal operating we find that the ¾-in. service will supply up to a 3 or 4-family home depending somewhat upon the pressure. The use of the flushometer type of toilet has complicated this somewhat causing us to put in 1-in. services where formerly the ¾-in. was sufficient. We put in none smaller than the ¾-in.—G. W. Pracy, Superintendent, City Distribution Division, San Francisco Water Department.

Marshalltown, Ia.

The best water service is the one that gives the best service for the longest period of time at the least amount of cost. Cast iron, lead, copper and galvanized iron are all used in water service lines. Cast iron and lead are undoubtedly long lived materials, but their first cost for small services must be considered high. Galvanized iron pipe is comparatively short lived in Marshalltown, but is the cheapest installation. The life of copper pipe services have not as yet been determined, but it has been demonstrated here at Marshalltown that it is a better material for water services than galvanized iron. Copper pipe costs so little more than galvanized iron pipe that we are recommending its use extensively.

A water service should be of such size as to furnish adequate water to the consumer, but it is a mistake to make the service too small. Here at Marshalltown we limit the size of a domestic service to ¾-in., but permit any one to put in a larger service if they want it.

Based on our experience here, we are not permitting galvanized pipe between the main and the curb stop. We give the property owner the right to choose between cast iron, lead and copper, but since copper is the cheaper pipe to use up to 2-in. size most of the water services in Marshalltown are being laid of copper. We recommend that all services over 2-in. in size be made of cast iron.—H. V. Pedersen, General Manager, Marshalltown, Water Works.

Ashland, Ky.

We have standardized on ¾-in. in copper service pipe with ¾-in. corporation cocks and ¾-in. curb cocks.—W. S. Patton, Manager, Ashland Water Co.

Brawley, Calif.

We are using ¾-in. and 1-in. copper services. We sometimes split 1-in. service to two ¾-in. services at curb. We charge $15 for ¾-in. service and $17.50 for 1-in. service.—C. J. Park, City Engineer.

Rushville, Ind.

The minimum size is a ¾-in. copper service; increased from this according to the demand.—Harry Petry, Superintendent City Water Plant.

Reading, Penna.

Our "Rates, Rules and Regulations" have the following clauses regarding service:

Where ½-in., ¾-in. and 1-in. corporation cocks are used, not less than 3 ft. of lead or copper pipe shall be attached to the corporation cocks by means of a well-made water-tight joint.

Where 1¼, 1½, and 2-in. corporation cocks are used, the service pipe shall be connected without the use of lead pipe by means of straight long turn elbows, nipples and "Kewanee" or all brass unions. All fittings other than unions shall be either galvanized wrought or malleable iron, lead-lined wrought or malleable iron or cast iron. The first elbow shall be attached to the corporation cock and followed with nipples, union and second elbow for a distance of approximately nine diameters of the pipe from center to center of elbows. The direction of this portion of the connection shall be ap-

proximately in line with the water main. The next portion of the connection shall consist of a nipple and a third elbow and be not less than six diameters in length, between elbow centers, and shall extend upwards or downwards to reach the proper depth of the service pipe. The outlet of the third elbow shall run at right angles with the main.

The ½, ¾ and 1-in. service pipe shall be either brass, lead, lead-lined genuine wrought iron or galvanized genuine wrought iron.

The lead pipe used in any part of a service pipe or water connection shall have not less than the following weights per foot: ½-in., 2 lb.; ¾-in., 3½ lb.; 1- in., 6 lb.

No lead pipe larger than 1-in. in diameter shall be used on any water connection.

The 1¼, 1½, and 2-in. service pipes shall be either lead-lined genuine wrought iron, galvanized genuine wrought iron, cast iron or brass. No steel pipe or fittings shall be used in underground work.

Copper pipes may be used as water service pipes in addition to the various kinds of pipes specified above. The copper pipes so used shall be of seamless copper tubing, and shall have the wall thicknesses not less than the following:

Diameter in inches	Wall thickness Birmingham Wire Gauge
½	18
¾	16
1	16
1¼	16
1½	15
2	14

The copper service pipe may be connected directly with the corporation cock by means of a suitable coupling and when so connected shall be laid with an "S" bend beyond the corporation cock so as to provide for street settlements.

All material used shall be of approved make and quality.

At a distance of 12 in. from the curb line a round way tee handle brass curb cock or stop shall be placed in the service pipe, protected with an iron box of approved pattern brought up to the sidewalk level. It shall be the duty of the property owner to maintain the curb stop box in perfect repair and free from all foreign material, and maintain the top of the box at a level with the sidewalk, so as not to offer an obstruction to pedestrians. The property owner shall be held responsible for any or all damages that may occur by reason of a misplaced curb box.

Where sleeves and gate valves are used for the connection with the main, the service pipes shall be of either cast iron or galvanized genuine wrought iron. The curb cock, with this type of connection, may be omitted if a cast iron gate valve box of the design in use by the Bureau of Water is placed over the gate valve. Said box shall be brought up to the grade of the street and kept in perfect repair and free from foreign material.—A. R. O'Reilly, Chief Engineer, Bureau of Water.

Garden City, N. Y.

The following is a copy of Article III, Section 27 of the Plumbing Code of the Village of Garden City:

"Water service main sizes shall be determined by the Department of Public Works, the minimum size to be 1-in. lead AA, brass or copper, iron pipe, size as follows:

"Brass service 1-in. or larger shall have extra heavy brass fittings and shall be best quality extra heavy seamless drawn, semi-annealed and shall be free from surface defects inside and outside, clean and of uniform color and quality, and true to gauge. It shall correspond to standard size iron pipe and shall take the standard iron pipe thread.

"Copper service 1-in. or larger shall have extra heavy copper fittings and shall be best quality, extra heavy, seamless drawn, semi-annealed, and shall be free from surface defects inside and outside, clean and of uniform color and quality, and true to gauge. It shall correspond to standard size iron pipe and shall take the standard iron pipe thread."—C. R. McKay, Superintendent of Public Works.

Akron, O.

All new service pipe less than 2 in. in diameter may be lead, brass or copper pipe from main to property line. All services 2 in. or over in nominal size are cast iron and conform to specifications of the American Water Works Association, extending from the main to the meter.

The minimum diameter of service pipe is ¾ in. and in no case is it less than the diameter of the tap controlling it.

Each service less than 2 in. supplying a property is equipped with a curb cock or stop cock located not less than 18 in. from the face of the curb or not less than 6 ft. from the property line, for the purpose of turning water on or off. Not more than one property is supplied without additional curb cocks being installed.

Each curb cock or stop cock is provided with a standard curb box with wrought iron adjustable section and known as the "Akron pattern curb box." Curb stop is from the type known as "socket head, inverted key, round way curb stop."

All connections between lead and iron pipes are made with brass soldering nipples and wiped joints. All connections between lead pipe and lead and brass are made by means of wiped, soldered joints not less than 2 in. in length, prepared, tinned and fused. All joints are uniform and of the size known as "heavy." Solder used is of the grade known as "extra fine" and the outside diameter of the wiped joint at the center is at least ¾ in. in excess of the outside diameter of the lead pipe. Soldering nipples are extra heavy cast brass.

Installation of service pipe less than 2 in. in nominal diameter from the main to the property line consists of tapping main, inserting corporation cock with proper couplings, laying lead, brass or copper pipe of proper size from the main to 18 in. back of the curb, providing stop cock with the approved type of stop-cock box, with cover marked "Water" and copper or brass pipe of the proper size to the property line where a coupling is left for proper connection to the owner's pipe. The obligation of the city terminates on the property side of the curb or stop cock, insofar as maintenance is concerned.

Ordinary domestic services are installed in the following sizes: ¾-in., 1-in. and 1¼-in.

A flat price for such service is made based only on the width of street, regardless of the location of the main within the street, an additional charge being made for repaving.

For the past several years, ¾-in. domestic services made by this department consist almost entirely of copper tubing. Domestic services 1 in. and 1¼ in. in size are still being made using extra heavy lead pipe.—W. R. LaDue, Assistant Superintendent.

MEETING NORTH CAROLINE SECTION A. W. W. A. AND SEWAGE WORKS ASSOCIATION

ON November 2nd, 3rd and 4th, the North Caroline Section of the American Water Works Association held its annual convention, jointly with the North Carolina Sewage Works Association, at Greensboro, N. C.

The convention was opened by an address of welcome by the Hon. Paul C. Lindly, Mayor of Greensboro, with response by President H. S. Lyon, Director of Public Works, Rockly Mount, N. C. Then followed the opening paper by C. W. Smedberg, Past President, and Director of Public Works and Safety of Greensboro, which outlined the progress made in improving Greensboro's public works and described "The Water Supply and Sewerage Works of Greensboro."

Later a trip of inspection was made to the recently completed sewage treatment plant and the water purification plant at Greensboro—the engineering and design on both plants being the work of Mr. Smedberg.

In the evening the annual banquet was served over which City Manager I. C. Brower of Greensboro presided. The Maffitt Cup was presented for the second time to R. D. Beam, Assistant Engineer of the State Department of Health. The cup, donated by M'Kean Maffitt, Superintendent, Wilmington Water Department, goes each year to the member who has secured the largest number of new members for the North Carolina Association during the year previous.

The City of Greensboro fire department band supplied the music during the banquet and for the dancing which followed. On another evening the association was tendered a dance by the city of Greensboro for which the same band provided excellent music. We are told that there are no paid musicians in this band and further that its leader, the chief of the department, organized the band wholly from the existing personnel of the department. It is truly an excellent band of which Greensboro is justly proud.

The afternoon of one day and a portion of a forenoon was devoted entirely to papers and discussions on sewage treatment and industrial waste disposal, including a highly interesting "Round Table on Sewage Treatment Problems," led by E. G. McConnell, Engineer in Charge of Plants at Charlotte, N. C. Mr. McConnell, who is editor of The North Carolina Section Journal, and Secretary H. G. Baity, Dean of Engineering, University of North Carolina, are to be commended for the arrangements and excellency of the program. The registration of 250 may not represent the largest attended North Carolina meeting, but the concensus of opinion was that in quality of papers presented and entertainment no other North Carolina meeting has ever surpassed that held at Greensboro.

Left to Right: Emery J. Theriault, Principal Chemist, U. S. Public Health Service, Cincinnati, O. Wellington Donaldson, Fuller & McClintock, Consulting Engineers, New York, N. Y. H. G. Barty, Secretary, North Carolina Water and Sewage Works Association. J. Wrench, Sales Manager, Industrial Chemical Sales Co. New York, N. Y.

Mr. Smedberg received a deserved note of thanks for his part in making the convention so successful and enjoyable.

The 1932 convention will be held at Winston-Salem, N. C.

Officers elected for 1931-32 are:

Pres. William C. Olson—Consulting Engineer, Raleigh, N. C.

Vice-Pres. J. H. Lampley—Manager Water Works. Hendersonville, N. C.

Secretary H. S. Baity—Dean of Engineering, University of North Carolina, Chapel Hill, N. C.

Editor—E. C. McConnell—Engineer in Charge Plants, Charlotte, N. C.

PAPERS AND DISCUSSIONS

"Manganese in Reservoirs and Its Removal."—Perhaps the most interesting paper dealing with water treatment, disclosing a novel means of removing manganese, was that presented by **P. W. Frisk,** Chemical Engineer, The American Enka Corporation, Enka, N. C.

Mr. Frisk explained that his company produced artificial silk and that the quality of water supply constituted a highly important part of the manufacturing operations. The presence of iron or manganese could not be tolerated even in minute amounts and furthermore the water had to be about neutral in respect to alkalinity (pH value).

The supply impounded from a mountain watershed in a lake at 2900 ft. elevation and 3 to 4 miles long (fed by 9 small streams) had been filled in 1929. All went well until in the late Summer of 1930 when decomposition of organic matter had set in. This followed by a reservoir turnover in October resulted in a water very difficult to treat satisfactorily and manganese and iron had passed the sand filters when using alum and soda ash for coagulation. In the Summer and Fall of 1931 the trouble had been even more pronounced and something had to be done promptly if the manufacture of silk was to continue and the water requirement of 4 m.g.d. produced. The manganese in the lower reservoir strata rose to 5.5 ppm. whereas in the top 6 ft. it was but 0.55 ppm. prior to the turnover.

Hurried experimental work indicated that 75 per cent of the manganese if converted to manganic hydroxides could be taken out in the coagulation basins with proper chemical treatment of water drawn from near the surface of the reservoir. The application of permanganate of potash to the prechlorinated water, fortified by increased alum and soda-ash dosage had proved effective. For each ppm.* manganese present in the raw water 1.4 ppm. of permanganate ($KMnO_4$) had been required for best results. Residual chlorine was carried through the entire plant using a dosage of 1 ppm. or more in the raw water during the permanganate treatment. A pH value between 6.8 and 7.0 in the coagulated water had been required.

Subsequently aluminate of soda had been applied along with the alum, etc., in the following proportions—Alum 2.83 g.p.g.,† Sodium Aluminate 0.22 g.p.g., Soda 1.45 g.p.g., Chlorine 1.5 ppm., Permanganate 0.68 ppm. at a resulting pH value of 6.5 to 6.8. By such treatment 0.7 to 1. ppm. of manganese had been satisfactorily dealt with in the raw water taken from the 6 ft. depth in the reservoir.

It had been found that practically all of the manganese reaching the filters had been removed by the upper 2 in. of the sand bed.

The salient feature of the treatment at Enka seemed to be the effect of the permanganate in conjunction with prechlorination and the bulkiness of the floc produced by the alum-aluminate combination was helpful in "sweeping out" the manganese. Usually to remove manganese completely a pH value in excess of 9.0 must be maintained in floc formation but such high pH value would not be acceptable in artificial silk production and therefore the treatment evolved at Enka, though expensive, was essential in this case.

*Throughout the abbreviation ppm. signifies parts per million. 1 ppm. =8.33 lbs. per million gallons of water.

†G.p.g. signifies gains per gallon. 1 g.p.g.=143 lb. per million gallons.

"The Minimum Flow of North Carolina Streams" was the subject of the paper presented by **Chas. E. Ray,** Principal Assistant Engineer, North Carolina Department of Conservation and Development, which called attention to the fact that the equitable and economic usage of streams was becoming more essential than ever before in North Carolina and that the drought of 1930 had shown the need for more adequate stream data covering a greater number of streams than now is available.

From studies made of available data is appeared that it would be probable that a stream in the western section of the state with as much as 50 square miles of drainage area might actually stop flowing during a long dry period and that one with as much as 1000 square miles watershed area might decrease to a flow of between 0.2 and 0.4 cu. ft. per second per square mile.

The droughts of 1925 and 1930 in North Carolina had been of about the same degree of dryness and certain streams had dropped to approximately 13 per cent of the normal annual flow or only 46 per cent of the average annual low flows.

Streams in certain sections of the State had dropped below 50 per cent of the average minimum flows and this represented serious conditions. Such extended low flows had been observed only twice in 42 years but there had been three periods of two years each in the 42 years (equivalent to 1 year in 7) when the average flows were less than 60 per cent of the average low flows.

From the data available it would seem proper to predict that unless stream gaging records are available an estimate of low stream flows to be expected might easily be 100 per cent wrong. In 1926 the Platte River, for example, with 150 sq. mile drainage area flowed less than 0.7 second-feet for a period—i. e., less than 500,000 gal. per day.

E. D. Burchard, representing the U. S. Geological Survey in North Carolina, made it plain that more funds are needed to keep up existing stream gaging stations and that he hoped some means might be forthcoming to provide adequate maintenance and to extend the stream gaging work in North Carolina. Studies of smaller drainage areas seemed probably more important from a water-supply standpoint than the larger areas.

"Pollution Hazards of Ground Water Supplies" by **C. H. Eastwood,** Wallace and Tiernan Co., Newark, N. J.

Illustrated by lantern slides the paper by Mr. Eastwood depicted the way in which several well known water-borne epidemics had been the result of groundwater contamination from hidden sources of pollution. The pollution of wells at Fond du Lac, Wis., Santa Ana, Calif., and Bad Axe., Mich., were graphically shown.

Reference was made to the surveys of groundwater quality in Texas made by the State Department of Health in which their records of selected wells had shown 25 per cent to be safe during the first year but after two years of sampling only 12 per cent of the analyses had shown satisfactory results.

Statistics during the period 1920-1929 had revealed that 16.6 per cent of all typhoid cases traceable to public water supplied could be charged to ground water supplies and that 23.6 per cent of all kinds of

water-borne epidemics had been caused by ground water.

Mr. Eastwood cited court decisions allowing damages to persons contracting disease from public water-supply and that constant analyses and chlorination might be depended upon as more satisfactory and economical than paying damage claims and court costs.

Mr. Burchard, in reply to a question as to the present relative levels of ground waters as compared with pre-drought periods, stated that the levels had not come back since the 1930 drought and that this condition may prove serious during 1931 and 1932.

"Contamination of Ground Water by Impounded Garbage Plant Wastes" by **C. K. Calvert,** Chief Chemist, Sewerage Commission of Indianapolis, Ind.

Mr. Calvert being unable to attend the meeting on account of illness, his paper was read by Secretary **H. G. Baity.**

The water taken from wells to supply the Indianapolis sewage treatment plant, and the garbage reduction plant adjoining, had suddenly become very hard and extremely high in iron content.

The trouble had been traced to acidic waste liquors from the reduction process of garbage disposal. These liquors being too heavy a burden on the activated sludge process could not be treated in the Indianapolis sewage plant and had been lagooned in pits awaiting opportunity to discharge on river rises. The pits were 500 ft. from the nearest well which 8 months after the liquor storage had been started, began to show contamination. Total hardness had increased to 800 parts per million and organic nitrogen to 18 parts. The free carbon-dioxide rose to 330 parts and the iron to 12 parts per million. Estimates put the garbage liquor content of the well water at about 9 per cent.

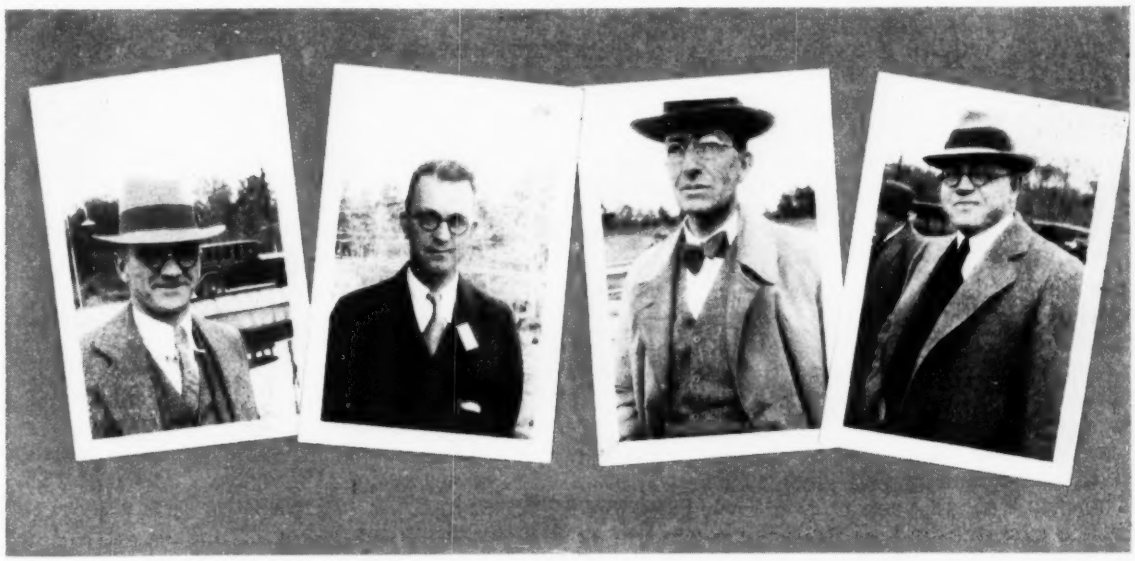
Experiments with garbage liquor, having an acid content equivalent to 3000 parts per million of CaC_3, in contact with some of the underyling limestone gravel disclosed the relatively rapid rate of conversion of the calcium carbonate to soluble salts and free carbon dioxide.

Mr. Calvert put forward the suggestion that bacterial activity had played a part in the phenomena and also called attention to the heavy growth of slime which had appeared in the power house steam condenser tubes as result of the well water contamination by organic matter and that intermittent chlorination of the condenser water had been required to eliminate the slime.

"The Use of Powdered Activated Carbon in Taste and Odor Control" by **J. S. Whitener,** Professor Sanitary Engineering, N. C. State College, Raleigh, N. C.

In his paper Prof. Whitener recounted the progress made with powdered activated carbon for taste and odor elimination from potable waters.

He had found powdered carbon most successfully used at a number of water purification plants. In some cases it had been applied to the raw water and at other places it had been more effectively used by adding it to the water entering the filters from the coagulation basins.



Left to Right: E. G. McConnell, Engineer in Charge of Plants, Charlotte, N. C. F. W. Jones, George Gascoigne, Consulting Engineers, Cleveland, O. J. W. McAmis, Superintendent Water Department, Greenville, Tenn. [The First Man to Employ the Ammonia-Chlorine Treatment in America.] C. W. Smedberg, Director of Public Water Works, Greensboro, N. C.

Among his summary of results he stated that tastes which might be caused by prechlorination are eliminated; that aeration when pumping is required is probably more costly than the use of powdered activated carbon for odor removal; that its use in quantity usually sufficient (2 ppm. or thereabouts) has not shortened filter runs; that aside from increasing the pH value and removal of impurities it has no other effect on the water; and that its use had entailed an added operating cost of between $0.35 and $1.30 per million gallons, which is justified when the benefits derived are taken into consideration.

In reply to a question **Mr. J. Wrench,** Manager, Industrial Chemical Sales Co. of New York, outlined the methods of activated carbon preparation and the qualities possessed by the different grades of activated carbon. He then asked permission to read a humorous poem entitled "Ye Pilgrim's Progress" (printed on another page in this issue) which would, he thought, give some of the several attributes of activated carbon.

Mr. Wrench said that he had also been given to understand that experimental work with activated

carbon in the South had shown it to have some merit in taste improvement of a "native beverage" other than H_2O. Judging from the ripple of laughter a number of members seemed to have been "experimenters."

"The Ammonia-Chlorine Process for Water Treatment in the United States" by **J. F. T. Berliner** and **Arthur E. Howe,** National Ammonia Corporation, Philadelphia, Pa.

In the absence of both authors their paper was read by the secretary.

Messrs. Berliner and Howe pointed to the fact that now more than 200 plants are using ammonia in conjunction with chlorination as contrasted to five installations two years ago. Experience had indicated that at filtration plants only when used in conjunction with prechlorination should the ammonia be applied prior to filtration. In passage through the filters considerable ammonia would be removed or oxidized thus requiring a greater dosage than when applied to the filter effluent.

There could be no definite ratio of ammonia (NH_3) to chlorine (Cl) prescribed to cover every case. In some instances the ratio required had been 2 NH_3 to 3.Cl and in others only one-half as much ammonia as chlorine had proved satisfactory. The best and most economical ratio in each instance remained to be determined by "cut and try" methods.

While tastes could be prevented from being produced by the process there were certain tastes such as "mouldy" and "musty" which could not be controlled probably because the water prior to chlorination had the taste already present.

As to algae control, the authors had found ammonia-chlorine treatment just as effective as chlorination alone, but a trifle slower in action perhaps. The process had been very effective in eliminating slime growths and bacteria from the mains and dead-ends on the pipe system. This had really been one of the marked advantages from the use of ammonia and could be attributed to the sustained chlorine effect for exceptional distances away from the plant. Furthermore a high residual of chlorine could be maintained in the pipe system without taste production which in itself offered several advantages.

The argument as to increased contact period required for high efficiency of bacterial destruction when ammonia was employed had not held in all cases but they (the authors) believed that a contact of 2 hours should be provided when the water temperature is low and the pH value relatively high. The contact required would be reduced appreciably however if higher residual chlorine was maintained and that this was entirely practicable of accomplishment without chlorinous taste production. To provide longer contact the process might be applied in the form of prechlorination, of the raw water with advantage.

Industrial applications of the ammonia-chlorine process had been proving more economical and effective than ordinary chlorination when used for "slime" elimination in paper mills, from condenser tubes in power plants, for "Rayon" bleaching and other miscellaneous applications.

Regardless of other attributes the authors thought that ammonia treatment of water would persist because of its value in sustaining sterilizing values of the chlorine applied and the possibility of maintaining almost any residual chlorine content desired without taste complaints from water consumers or patrons of swimming pools.

Prof. H. G. Baity, cited a case at Chapel Hill, N. C., wherein some newly tarred roads across the water shed had contributed a high dosage of phenols to the water supply following the wash by heavy rains. The result had been a terrific chlor-phenolic taste in the Chapel Hill water which fortunately was as promptly as possible eliminated by ammoniation. A cylinder of ammonia had been secured from the local refrigeration plant and although the equipment used in feeding the gas ahead of the chlorine had been crude, the process was immediately effective and that he was satisfied that the ammonia-chlorine treatment would with certainty prevent chlor-phenol tastes if no others.

L. H. Enslow said that the suggestion of pretreatment of the raw water by the ammonia-chlorine process whenever contact periods were limited beyond the filters was well taken. Long contact would prove particularly advantageous in cold weather or whenever the water is more alkaline than pH7—notably in conjunction with softening practice. At pH values above 7. a preponderance of monochloramine is produced and at pH 8.4 and above only monochloramine is produced and in this form the chloramine is slower to act. Particularly was this the case at temperatures lower than 10° C.

Mr. Enslow said that he would like to introduce to those present, who did not already know him, the pioneer "ammoniator" in America. **Mr. J. W.** McAmis, Superintendent of Water Works, Greeneville, Tenn., was thereupon requested to stand up. (Applause.)

(Editor's Note: Mr. McAmis introduced ammoniation of water into American practice at Greeneville, Tenn., in 1927, and with most satisfactory results in taste prevention.)

"The New Iron Removal Plant at Warrenton, N. C." by **M. F. Trice,** Assistant Engineer State Department of Health, Raleigh, N. C.

Mr. Trice recounted the experience of the Warrenton, N. C., water works in dealing with a well water supply high in soluble iron, manganese, carbon dioxide and hydrogen sulphide gas.

In 1930 the town with but 1,000 consumers served by the existing water system built an iron removal filtration plant with coke tower aerators, chemical feed, mixing chamber, coagulation basins and a pressure type filter.

The plant had been built under the supervision of **H. R. Skillman,** Superintendent of Water Works at Warrenton at the remarkable figure of $7,395. The costs of operating the plant had been but 15 per cent more than the cost of operating the old system.

The coagulated settled water is pumped under 75 lb. pressure through the pressure type filter direct to the system at rates of 2.5 gal. per square foot sand area per minute. The plant had been very effective in removal of dissolved gases, manganese and 65 per cent of the iron which previously had been as high as 4.8 ppm. at consumers taps. The pH value carried in the finished water from the new plant had been above 9.0, but still there had been found 0.4 ppm. iron (sometimes more) in the business district, and in the outlying districts the iron had increased to as much as 0.8 ppm. which indicated that picking up of iron from the mains had been continuing even at pH values in excess of 8.5, normally considered to be a

film depositing water rather than an aggressive water. Even-so the town had been very much benefited by the new plant and the consumers were pleased.

H. R. Skillman, remarked that regardless of the somewhat deficient results indicated by analyses the citizens of Warrenton, were highly pleased with the water since starting the new plant and that they at Warrenton felt indebted to Mr. Trice and the State Department of Health Engineering Division for the advice and assistance given.

WATER TREATMENT PROBLEMS: A ROUND TABLE DISCUSSION—C. W. SMEDBERG, LEADER

The Use of Sulphate of Ammonia in Taste Prevention, was covered by **L. L. Hedgepeth** who reported that at Raleigh, N. C., sulphate of ammonia (NH_4SO_4) had been used with good effect. They had been able to maintain a residual of 0.2 ppm. available chlorine in the outlying sections of the pipe system with the elimination of the pin-point colonies of bacteria (aftergrowths). Lime is applied to raise the pH of the filtered water to above 8.2 and he thought that under such circumstances the use of the sulphate was equal to the use of anhydrous ammonia. When the pH of the water is below 7.2 then he thought that the use of ammonia would produce better results. The sulphate might be fed with the alum or in case it was to be applied to the filtered water it could be fed separately and already it had been used successfully at some large plants.

R. D. Beam, commented on the fact that Raleigh had found blowing of "dead ends" much less of a job since the ammonia treatment had been started. The water cleared up much quicker during the blowing operations which indicated that some corrosion probably had been caused indirectly by biological action out in the dead ends. Furthermore the open clear water reservoir has not had to be cleansed as frequently during the past year.

J. S. Whitener stated that the Raleigh scheme of feeding ammonian sulphate consisted of mixing powdered alum and the ammonia salt in ratio of 10 lbs. NH_4SO_4 to 200 lbs. filter alum when filling the dry feed machines.

Chlorination as Applied in Emergencies was covered by **W. A. Savell.** The advantages of having available a supply of a stable hypochlorite for use to supplement the use of liquid chlorine or to substitute for liquid chlorine in case of necessity were stressed. Cases were cited to illustrate how inexpensive equipment consisting of small solution tanks had been used for feeding hypochlorite solutions for algae control and in emergencies where otherwise chlorination could not have been provided so easily or promptly. In some cases the hypochlorite had been applied to reservoirs from a boat by broadcasting it over the water surface. At one place a very serious algae condition in a 20 m.g. pond had been corrected by application of 800 lbs. of "H.T.H." thus applied. The use of copper sulphate had been ineffective on that particular growth of algae which gave the water the appearance of pea-soup.

Left to Right: A Group of "Ambitendent" Scientists Getting "Low Down" on Greensboro Sewage Treatment Plant. L. L. Hedgypeth, Technical Advisor, Pennsylvania Salt Mfg. Co., Philadelphia, Pa. W. E. Vest, Superintendent, Water Department, Charlotte, N. C. Dean H. G. Baity (Center) and Class from U. of N. C. Looking Over Sewage Treatment Plant at High Point, N. C.*

To clean up dirty filters "H.T.H." had been used successfully by applying it to the beds while covered with a shallow depth of water and thereafter allowed to stand over night before back washing. In some of the smaller water works "H.T.H." had been used continuously by preparation of a solution carrying 600 ppm. available chlorine and feeding through an orifice box. Small sewage plants had also found its use practical and not too expensive.

In reply to a question Mr. Savell stated that "H.T.H." produced by his company (The Mathieson Alkali Works) was a high test hypochlorite containing 60 to 64 per cent available chlorine and that strangely enough a container of "H.T.H." would have in it more chlorine than would a cylinder of liquid chlorine of the same gross weight.

L. H. Enslow pointed out the successful use of chlorine for algae control and slime control and that in some cases copper sulphate would be less effective whereas in others copper sulphate alone or a combination of copper and chlorine would prove overall most effective. At the Baltimore sewage works a scheme for securing copper and chlorine in combina-

**See editorial page for definition.*

tion had been devised. It consisted of a tower filled with scrap copper and upward through this was discharged chlorine water from a chlorinator. The effluent would contain any desired weight of copper depending upon the quantity of chlorine fed through. In this scheme the copper had been attacked and converted to chloride of copper and excess chlorine could be had in the tower effluent or might be added to the outlet pipe beyond the tower to the extent desired.

It had been interesting to note that certain forms of algae had the power of increasing the pH value of waters to 9.5 if not higher, merely by breaking down the bicarbonates to normal carbonates and using the CO_2 thus removed as carbonacious food material.

In reply to further questions Mr. Savell stated that "H.T.H." holds its chlorine strength for a year or more and can be fed from a dry feeding machine if desired; that it contained about 3 per cent of hydrated lime and dissolved very easily.

Cleaning Filter Sand at Goldsboro, N. C., was described by **A. A. Scott,** Superintendent Filter Plant. The dirty sand and mud balls had been removed and the gravel cleaned. One-half the sand was replaced and then a layer of caustic soda was added and then the remaining sand and more caustic added to the surface. The bed was then submerged and allowed 6 hours to stand after which it was drained to waste, refilled and washed thoroughly and filtered to waste again until the caustic had entirely disappeared—(about 1 hour).

The treatment consumed only 75 lb. of flake caustic soda per half million gallons unit and the expense of sand cleaning was $195 less per filter than new sand and replacement would have cost. The sand had really been better than new sand and wash water required had been reduced materially.

Difficulties in Filter Plant Operation at Durham, N. C., were recounted by **A. M. Worth.** The use of ammonia with chlorination had not corrected the troubles from stagnation on dead ends to the extent anticipated. Durham had suffered from Cyclops and Daphnia in the coagulation basins and on the filters. His experience with ammoniation had on the whole been unsatisfactory.

Papers of Sewage and Industrial Wastes

"Modern Measures in Water and Sewage Treatment" by **E. J. Theriault,** Principal Chemist, U. S. Public Health Service, Cincinnati, O.

Mr. Theriault called attention to the increasing heavy burden which stream pollution is placing on filtration plants and referred to intestinal disorders that had been traced to polluted water supplies which had been rendered bacterially safe by filtration and chlorination. Heretofore freedom from bacteria had been considered a sufficient index of the potability and non disease producing quality but experiences during the 1930 drought period had indicated that the high concentration of pollution had produced toxins or some product of decomposition which ordinary water purification practice had not eliminated. In consequence there had been considerable intestinal disorders along the Ohio River which had been traceable to the water supply. A similar disturbance occurred at Charleston, W. Va., during the recent drought where a heavily polluted water had been treated by best known procedures.

Taste production might be caused by domestic sewage in water as well as trade wastes. It had been shown that 500 parts of phenol per billion would be found in the average decomposed domestic sewage. He believed it essential to reduce stream pollution in order to render the Ohio and some other rivers in America fit at all times for use as sources of domestic water supply. He thought perhaps the use of activated carbon might prove helpful in removing soluble products of an objectionable nature from waters that coagulation and filtration alone did not appear to be capable of eliminating.

The fluoride content of waters had been receiving some interest recently and there seemed to be a happy medium perhaps between too high fluoride content which caused mottled teeth and no fluoride content. Mottled teeth did not decay and therefore fluoride might prove of some value in concentration just below that which produced noticeable tooth mottling.

In sewage treatment Mr. Theriault had observed progress of the art considerably in advance of the understanding of the processes involved. This had been particularly true in the activated sludge method of treatment. He had observed that there was too little appreciation of the rapidity with which the 1 per cent of solids in the sludge itself used up dissolved oxygen from the liquor. The studies made recently by the U. S. Public Health Service had indicated a demand for oxygen by one liter of the sludge (99 per cent water) of roughly 10 mgm. of oxygen per minute which was far beyond any realization. It was evident therefore that all clarification tanks must have anaerobic conditions existing at some point within the sludge zone. Reaeration or reactivation of the sludge seemed to be more important than realized but that the oxygen input had to be more rapid than the observed 10 ppm. depletion per minute if reaeration was to prove helpful.

In reply to questions Mr. Theriault stated that it seemed essential to return sludge which would have sufficient dissolved oxygen to satisfy at least the immediate oxygen demand of the incoming raw sewage otherwise the usual plant overloading difficulties could be anticipated. Furthermore, oxidation proceeded in the aeration tanks in two distinct stages and that 90 per cent of the 5-day oxygen demand by the carbonaceous matter in sewage had been removed from solution in 10 minutes of aeration in contact with activated sludge. The use of iron salts as catylists to assist biological oxidation had been tried without success.

Mr. McConnell believed that precipitation agents applied at the first signs of sludge bulking might prove very effective as indicated by his experience with small additions of clay and coagulants.

Mr. Enslow complimented the author on the interesting disclosures made in his paper and said that Mr. Theriault's statements seemed to tie in perfectly with observed conditions at several plants. It had been his thought for some time that perhaps the addition of some form of finely divided carbon to the aeration tanks might accumulate a store of oxygen by adsorption and that this oxygen would be released slowly to the sludge during its stay in the settling tanks and thus stop the "reversion" which sets up within the sludge the moment the sewage leaves the aeration units.

"Some Notes on the Operation of Sewage Treatment Plants," by **Wellington Donaldson,** Fuller & McClintock, Consulting Engineers, New York City.

Mr. Donaldson had observed a marked improvement in sewage plant operation during the past few years and this had been due to increased interest of municipalities in sewage treatment and the rapid mechanization of sewage works.

The activated-sludge process continued popular but suffered from overloading and variations in sewage quality more than other processes. Bulking of sludge remained an unsolved problem and seemed to always accompany the appearance of filamentous sphoerotilus growths in the aeration tanks and that oxygen depletion seemed to be responsible for the sphoerotilus growth and bulking sludge.

Remedial measures had been tried at the Tenefly, N. J., plant to control bulking. The use of coagulants had been ineffective but lime when carefully added to the inlet end of the aeration tanks had helped considerably. The control of lime application had been essential, because too little or too much will not produce results. The pH value of the influent to the clarifiers must be raised to pH 8.8 or thereabouts for best results. In practice a pH of 8.6 to 8.8 was sought at the outlet end of the aeration units.‡

In reply to a question Mr. Donaldson stated that between 25 and 30 grains of hydrated lime per gallon of sewage had been required to raise the pH value of the mixed liquors to that desired (8.6+) and this was naturally an expensive remedy for bulking.

"What Constitute Offensive Odors About a Sewage Treatment Works," by **F. W. Jones,** George B. Gascoigne, Consulting Engineer, Cleveland, O.

First recounting the variety of odors which might eminate from sewage works and the several possible sources of odors Mr. Jones then dealt with their eradication or control. Odor "habits" were also covered and it was observed that odor prevention had proven the most effective remedial measure to apply.

Odors could be destroyed in a large measure, should the sewage reach the plant in bad condition, by application of chlorine either with or without lime used in combination with it. The use of prechlorination in odor prevention had met with such success as to warrant its inclusion in plant design and had won a permanent place in general sewage treatment.

Mr. Jones had observed that cleanliness and general plant appearance were highly important factors in combating odor complaints which might be the result of psychological as well as actual effects.

"Progress With the Lime-Chlorine Treatment of Sewage," by **Linn H. Enslow,** The Chlorine Institute, New York, N. Y.

The several general advantages to be expected from the use of the "lime-chlorine" process were reviewed. The production of chloramines in the sewage with sustained germicidal and fungicidal effects seemed to be the more interesting and important aspects. There likewise had resulted some economy over and above the use of chlorine alone.

At Baltimore the process had been applied to the sewage plant effluent to clear up an algae condition caused by 60 million gallons daily of sprinkling filter effluent entering Back River—a tidal estuary. The results had been sufficiently encouraging to continue the treatment over the Summer of 1932 involving 3,000 lb. of chlorine per day and 4,000 lb. of hydrated lime.

The results secured at the Dayton, O., sewage plant employing prechlorination were reviewed. To avoid repetition here the reader is referred to an article appearing elsewhere in this issue by M. W. Tatlock, Superintendent Dayton Sewage Works. The "lime-chlorine" process was employed.

Wellington Donaldson referred to the simplicity of the "lime-chlorine" set up arranged for at the Middletown, N. Y., sewage plant. The process would be expected to result in more sustained chlorine effects in order to secure improved stream conditions below the plant.

"Hosiery Mill Wastes as Related to Stream Pollution and Sewage Treatment," by **M. F. Trice,** State Department of Health, Raleigh, N. C.

Mr. Trice's paper contains probably the most valuable information yet available on the several kinds of wastes from hosiery mills, their source, concentration in terms of oxygen demand and population equivalent and the quantities produced per hundred weight of hose passing through the mills.

Spent dye wastes and rinse water constitute the principal wastes from cotton, silk and rayon dying. Their content of Glauber's salt (Na_2SO_4) rendered the dye waste objectionable for handling in sewage plants as did the color and oxygen demand value. Cotton dying wastes had higher oxygen demands than those from silk or artificial silk dyeing.

The worse wastes encountered had been those from degumming processes which had been found in terms of oxygen requirement to be equivalent to sewage from 34 to 44 persons for each 100 lb. of hose processed.

Wastes from the following processes had been thus far measured and evaluated.

Process	Volume*	Index of Strength†
Direct Black Dyeing	1000 gals.	13.7
Sulphur Black Dyeing	540 gals.	5.0
Peroxide Bleaching	820 gals.	8.8
Chlorine Bleaching	1250 gals.	4.1
Regular Degumming	650 gals.	44.0
Bleach Degumming	800 gals.	33.8

*Per 100 lb. of hose processed or dyed.

†Population equivalent—i.e., the oxygen demand value of wastes expressed in terms of the number of people required to produce domestic sewage sufficient to equal in stream or sewage plant loading the wastes from each 100 lbs. of hose processed per day.

The values had been derived by analyses made in the State Department of Health Laboratories of more than 300 samples of the various wastes.

SEWAGE TREATMENT PROBLEMS: A ROUND TABLE DISCUSSION—E. G. MCCONNELL, PRESIDING

"Operating Costs at Gastonias' Activated Sludge Plant" were reported by **R. W. Haywood,** Chemist, Gastonia, N. C.

Mr. Haywood reported that at Gastonia the plant was handling an average of slightly more than one million gallons of sewage per day using 2.03 cu. ft. of air per gallon at a cost of $54.33 per million gallons to cover plant operation expense. This had been equivalent to $41.86 per 1,000 lb. of dry solids removed. Ferric chloride had been continued as the sludge conditioner (7.5 lb. $FeCl_3$:6 H_2O per 1,000 gals. sludge) and the Oliver vacuum filters had handled 1,077 lb. of dry solids per hour.

In efficiency the plant had removed on the average 76.5% of the solids and the B.O.D. reduction had averaged 77.5 per cent.

Textile plant wastes including vat and sulphur dyeing wastes had increased the oxygen demand of the sewage to 500 parts per million and had given them trouble at times but usually all color except

‡Additional observations of interest appear in Mr. Donaldson's paper which, in condensed form, is printed elsewhere in this issue.

50 to 60 parts per million could be removed by increased air application.

In reply to questions Mr. Hayward stated that at Gastonia they had carried only 0.2 to 0.25 parts per million of dry weight solids in the aeration tanks. That bulking in Winter had been particularly troublesome and occasionally the suspended solids in the effluent would run as high as 150 to 200 parts whereas the normal high figure would be around 25 parts.

Mr. Worth of Durham had found by experimental plant operation that sprinkling filters gave just as satisfactory purification of sewage containing textile mill wastes as did the activated sludge process but that color removal had been 50 per cent greater with the activated sludge process.

"Operating Costs at the High Point Activated Sludge Plant" was reported by **E. H. Moss,** Superintendent of Treatment Plants.

Mr. Moss reported that during the past 9 months operating cost had been $42.78 per million gallons of sewage treated at the High Point activated sludge plant which was handling about 50 per cent of its designed capacity. Power cost had averaged $850 per month treating an average of slightly more than one million gallons per day of purely domestic sewage with a B.O.D. value averaging 153 parts per million.

Sludge in the aeration tanks was carried at 25 per cent by volume and 0.4 per cent solids by dry weight.

Oliver vacuum filters were used for dewatering the sludge to a cake of 80 per cent moisture content which was applied to the land. Ferric chloride was being employed as the conditioning agent in the dewatering process.

"Operating Costs and Results at the High Point Sprinkling Filter Plant." Mr. Moss gave results and costs covering a full year of operation of the sprinkling filter plant treating 2.5 million gallons of sewage per day of which 16 per cent had been wastes from hosiery and textile mills.

The B.O.D. reduction had averaged 93.3 per cent, the color reduction 90 per cent and suspended solids reduction 85.6 per cent. The primary tanks had removed 68.5 per cent of the suspended solids. The final effluent had averaged 28 ppm. suspended solids content, B.O.D. of 24 ppm. and nitrate nitrogen 8.5 ppm.

Sludge gas had averaged 3,000 cu. ft. per day and the 65.5 per cent organic matter content of raw sludge had been reduced to 45 per cent in the digested sludge which was drawn at 90 per cent moisture content. A pH value of 6.7 in the digestion tanks was normally held and seemed sufficiently high. A temperature of 80° F. is maintained in the digestors.

Operating costs have averaged but $14.30 per million gallons of sewage treated.

E. G. McConnell reported operating costs of under $23.00 per million gallons at the Charlotte activated sludge plants, and replying to a question stated that the sludges produced had fertilizer values about as follows:

Activated Sludge	6% nitrogen (dry basis)
Digested Crude Solids	2% nitrogen (dry basis)
Activated Sludge and Crude Solids after digestion	4% nitrogen (dry basis)

Those Attending the Convention

The total registration at the Convention was 250, the list including the following:

J. E. Andrews, Knoxville Sand & Lime Co., Knoxville, Tenn.
J. M. Angell Jr., Water Works & Sewerage, 420 Lexington Ave., New York City.
B. D. Archer, Chemist, Water Department, Winston-Salem, N. C.
John L. Atwell, The A. P. Smith Manufacturing Co., East Orange, N. J.
H. G. Baity, Professor, Sanitary and Municipal Engineering, U. N. C., Chapel Hill, N. C.
Mrs. H. G. Baity, Chapel Hill, N. C.
R. D. Beam, N. C. State Board of Health, Raleigh, N. C.
C. H. Becker, R. D. Wood & Co., Chestnut St., Philadelphia, Pa.
Homer E. Beckwith, Dist. Mgr., Pitometer Co., Harrisburg, Pa.
Harwood Beebe, The Harwood Beebe Co., Engineers, Spartanburg, S. C.
Hiram Bell, Gray Concrete Co., Thomasville, N. C.
E. D. Blackwelder, Charlotte Water Works, Charlotte, N. C.
J. H. Bodenheimer, Samarcand Manor, Samarcand, N. C.
Warren H. Booker, Chief Engineer, State Board of Health,
O. L. Briggs, Supt. Water Department, Waynesville, N. C.
Sherwood Brockwell, State Fire Marshal, Insurance Dept., Raleigh, N. C.
I. C. Bower, City Manager, Greensboro, N. C.
Robert L. Brown, Paper Makers Chem. Co., Atlanta, Ga.
S. B. Bugher, Supt. Water & Sewer Dept., Reidsville, N. C.
J. L. Bullard, Supt. Water & Light Dept., Lexington, N. C.
E. D. Burchard, U. S. Geological Survey, Asheville, N. C.
E. J. Buttenheim, The American City Magazine, New York
E. P. Caruthers, State Board of Health, Graham, N. C.
F. E. Carroll, Mueller Co., Decatur, Ill.
Mrs. F. E. Carroll, Decatur, Ill.
C. E. Carter, Supt. Water Plant, Winston-Salem, N. C.
G. F. Catlett, State Board of Health, Raleigh N. C.
Mrs. G. F. Catlett, Raleigh, N. C.
W. W. Chaffin, Civil Engineer, Sanford, N. C.
J. P. Clawson, Dept. Conservation & Development, Chapel Hill, N. C.
J. D. Cochran, Supt. Water Department, Statesville, N. C.
Fred Coffman, N. C. State Board of Health, Raleigh, N. C.
M. H. Collins, Ransselaer Valve Co., Louisville, Ky.
Mrs. M. H. Collins, Louisville, Ky.
Julius Cone, City Councilman, Greensboro, N. C.
R. M. Cooksey, City Manager, Thomasville, N. C.
J. H. Copp, The Kalbfleisch Corp., Chattanooga, Tenn.
D. M. Councilman, Meter Department, Burlington, N. C.
E. R. Culbertson, Rep.-D.-N. Corp., Albany, Ga.
Jack Dabney, Glamorgan Co., Lynchburg, Va.
F. R. Darden, Williams Lime Co., Knoxville, Tenn.
G. T. Davielson, Supt. Water & Sewer Dept., Mooresville,
R. M. Davis, Supt. Water Department, Leaksville, N. C.
H. F. Davis, Wallace & Tierman Co., Charlotte, N. C.
P. D. Davis, Wm. M. Piatt, Durham, N. C.
F. H. Dawson, Darling Valve & Mfg. Co., Williamsport, Pa.
Harry O. Dean, Rapp Co., Inc., Atlanta, Ga.
L. E. Dempsey, Supt. of Sanitation, Greensboro, N. C.
F. D. Dimmick, R. D. Wood & Co., Richmond, Va.
P. J. Dishner, Sanitary Engineer, High Point, N. C.
Mrs. P. J. Dishner, High Point, N. C.
J. H. Dixon, Supt. Water Department, Liberty, N. C.
Mrs. J. H. Dixon, Liberty, N. C.
Margaret Dixon, Liberty, N. C.
F. G. Doggett, Chemist, Sewage Treatment Plants, Charlotte,
W. Donaldson, Fuller & McClintock, Engineers, New York
Frank C. Dorsey, Supt. Water Plant, Forest City, N. C.
Chas. H. Eastwood, Wallace & Tiernan Co., Newark, N. J.
Raymond E. Ebert, Chemist, Sewage Treatment Works, Winston-Salem, N. C.
Geo. C. Eichorn, City Purchasing Agent, Greensboro, N. C.
Mrs. Geo. C. Eichorn, Greensboro, N. C.
L. H. Enslow, Editor, Water Works & Sewerage, New York
H. C. Erwin, Jr., Hersey Manufacturing Co., Atlanta, Ga.
W. S. Eskridge, Pomona Terra Cotta Co., Greensboro, N. C.
W. J. Evans, Supt. of Filtration, Oxford, N. C.
Mrs. W. J. Evans, Oxford, N. C.
Miss Everett, Department of Public Works, Greensboro,
R. E. Ferguson, Hersey Manufacturing Co., S. Boston, Mass.
L. A. Fisher, Supt. Water Department, Concord, N. C.
Christos L. Floras, Graduate Student, U. N. C., Chapel Hill,
Vet Flowers, Supt. Water Department, Clayton, N. C.
John E. Floyd, District Sanitary Inspector, Asheville, N. C.
Mrs. John E. Floyd, Asheville, N. C.
Mrs. Dallas Forbes, High Point, N. C.
T. B. Ford, Jr., The Dorr Company, Inc., Atlanta, Ga.
P. W. Frisk, American Enka Corp., Enka, N. C.
Mrs. P. W. Frisk, Enka, N. C.

J. J. Gilbert, Link-Belt Co., Philadelphia, Pa.
J. L. Greenlee, Charlotte Water Dept., Charlotte, N. C.
M. N. Griffin, Griffin Foundry & Mfg. Co., Rome, Ga.
W. H. Hall, Duke University, Durham, N. C.
J. W. Harrell, Supt. Public Works, Williamston, N. C.
P. A. Hayes, City Councilman, Greensboro, N. C.
R. W. Haywood, Jr., City Chemist, Gastonia, N. C.
L. L. Hedgepeth, Pennsylvania Salt Mfg. Co., Philadelphia,
W. A. Hersey, Hersey Mfg Co., So. Boston, Mass.
O. C. Hill, Supt. Water & Sewer Depts., Louisburg, N. C.
J. L. Hodgson, National Meter Co., Atlanta, Ga.
Lawrence C. Hough, The Pitometer Co., New York City.
D. W. Ireland, Supt. of Plants, Burlington, N. C.
Donald F. Irvin, Oliver United Filters, Inc., New York City.
J. M. Ivey, Mathieson Alkali Works, Charlotte, N. C.
Robert V. Irwin, The Permutit Co., Spartanburg, S. C.
W. H. Jarrett, Supt. Water Department, Thomasville, N. C.
Howard A. Johnson, Supt. of Filtration, Danville, Va.
Mrs. Howard A. Johnson, Danville, Va.
E. M. Johnson, Supt. of Filtration, Monroe, N. C.
Mrs. E. M. Johnson, Monroe, N. C.
J. N. Johnson, State Board of Health, Waynesville, N. C.
W. R. Jones, Supt. of Filtration, Lexington, N. C.
Frank W. Jones, Sanitary Chemist (Garvoigne), Cleveland, O.
"Tarvia" Jones, Sales Engineer, Barrett Co., Durham, N. C.
Andrew Joyner, City Attorney, Greensboro, N. C.
J. P. Kavanaugh, Wallace & Tiernan Co., Charlotte, N. C.
E. W. Kearney, Supt. of Filtration, Mt. Airy, N. C.
C. R. Kennedy, Worthington Pump & Machine Corp., Atlanta, Ga.
V. B. Lamovreux, U. S. Public Health Service, Washington, D. C.
J. H. Lampley, Mgr., Board of Water Commissioners, Hendersonville, N. C.
Mrs. J. H. Lampley, Hendersonville, N. C.
L. I. Lassiter, Sanitary Engineer, Board of Health, Wilmington, N. C.
Harry L. Leon, Reading-Pratt & Cody Co., Charlotte, N. C.
C. F. Lewis, Consulting Engineer, Greensboro, N. C.
R. C. Lewis, Neptune Meter Co., Atlanta, Ga.
G. N. Linam, Sewage Treatment Works, Charlotte, N. C.
B. C. Little, Sec'y., Am. Water Works Assn., New York City.
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E. P. Meredith, Jr., Supt. of Filtration, Washington, N. C.
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A. M. Michael, Supt. of Water Works, Mebane, N. C.
J. C. Michie, Supt. of Water Works, Durham, N. C.
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Harvey N. Morgan, Water Department, Smithfield, N. C.
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W. F. Murphy, Lynchburg Foundry Co., Lynchburg, Va.
J. F. Nance, Filter Operator, Proximity Mfg. Co., Greensboro, N. C.
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Mrs. W. J. Parks, Lincolnton, N. C.
T. C. Paterson, Supt. of Water Works, Mt. Holly, N. C.
J. L. Perkins, Director of Public Utilities, High Point, N. C.
Mrs. E. L. Perkins, High Point, N. C.
John M. Perryman, Chicago Bridge & Iron Co., Birmingham, Ala.
P. A. Peterson, Neptune Meter Co., Atlanta, Ga.
W. M. Piatt, Consulting Engineer, Durham, N. C.
W. M. Pollard, Operator of Water Works, Smithfield, N. C.
H. N. Porter, Charlotte Water Works, Charlotte, N. C.
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Rev. R. Murphy Williams, Greensboro, N. C.
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TASTE AND ODOR REMOVAL

Successful Use of Activated Carbon at Newport News, Va.

By E. F. DUGGER
General Manager, Newport News Water Works Commission

E. F. Dugger

DURING the past few years the problem of taste and odor elimination or prevention in public water supplies has undoubtedly been one that has received foremost attention by those charged with the managment of the water works and the responsibility of producing potable water.

The water supply for the City of Newport News is derived from impounded lakes of a shallow nature, due to the general low elevation of the surrounding country, and to the danger of getting salt water from deeper excavation. The differnt forms of algae, especially those that produce objectionable tastes and odors, thrive rapidly in lakes of this nature. We, like many others, have for years had to answer the numerous customers complaining of the disagreeable taste and odor of the water at intervals during the algae growing season.

During the unprecedented drought of 1930 that continued up until April of this year, a considerable amount of normally flooded area of our reservoir became a veritable field of weeds and grass. Following the drought the precipitation during the months of April and May of this year amounted to 13.31 in., and as a result the heavy growth of vegetation was rapidly flooded. In a very short time we began to notice a much higher color and also a very pronounced taste and odor in the water.

Major Richard Messes of the Virginia State Health Department, through the kindness of Mr. W. L. Davis, manager of the Portsmouth Water Supply, began experimental work with activated carbon at the Suffolk Plant. The object of these tests were to determine the value of a powdered activated carbon for elimination of the objectionable tastes and odors from the Portsmouth supply. It was my pleasure to be present while these tests were conducted, and I was greatly impressed with the encouraging and satisfactory results.

Due to the insolubility of the carbon applied ahead of the filters none of it remained in the effluent. This in itself made quite an impression upon me, as this was the first chemical treatment of water that I have seen used in which no part of the chemical was passed on to the consumer, but instead was all collected on the filter beds.

The Suffolk water differs from the Newport News supply in that it has a very low alkalinity, whereas in our water the alkalinity runs about 90 parts per million. While there I ordered a quantity of carbon shipped to my plant in order that we might experiment with it in a water of high alkalinity, hoping that we could obtain similar results as those attained with the low alkaline water of Suffolk.

Our water, as previously stated, like most other impounded supplies, has always to some extent had a rather objectionable taste and odor during the late summer of each year. But due to reasons previously stated this condition came upon us earlier, and rather unexpectedly this year, and in a more aggravated form than at any previous time. This condition of the water was occasioned by the necessity to take water through one of the lower intakes from the main reservoir. Immediately the plant operator noticed a most disagreeable odor, not only in the plant, but at the intake. Tests revealed that all water from this and lower levels was practically devoid of dissolved oxygen.

Steps were immediately taken to apply the powdered activated carbon which we had just previously received, in the hope that we could alleviate to some extent this disagreeable taste and odor. A very homely contrivance was hastily set up, at a point to apply the carbon just prior to filtration. This equipment consisted of a Coca Cola barrel, with an electric hand drill equipped with wooden paddles as an agitator, and the necessary control valves. The solution was fed into the filter influent about 25 ft. from the first filter through a ⅝-in. hose extending to a depth of about 10 in. in the influent flume. The amount of carbon that we used for each barrel was 5 lb., and the control valve was set so that the barrel would empty in approximately one hour.

The consumption of water at this time was 4,500,000 gal. per day. Feeding the carbon at the rate of 5 lb. per hour or one-tenth of a grain per gallon, the cost of the treatment was approximately 75 ct. per million gallons.

The results obtained were very satisfactory, in fact they far surpassed our hopes in that within eight hours after treatment was started the filter effluent was free from all taste and odor. Continued tests have failed to reveal that filter runs have been shortened by the use of this treatment or have we ever found any of the carbon in the finished water.

We have continued the use of activated carbon since June 19, and we have had no complaints since that date from either taste or odor in the water. To my knowledge this is the first time in the history of our plant that we have not had serious complaints from customers in all sections of our system from both taste and odor during the period carried.

The product used at the Newport News plant was "Nuchar No. 2," supplied by the Industrial Chemical Sales Co. of New York.

Acknowledgment.—The above paper was read at the Lynchburg meeting of the Virginia Water and Sewage Works Association.

EDITORIALS

"Drought" or "Drouth"

TWO years of drought made necessary a definition of the word by the U. S. Weather Bureaus as follows:

> "A lack of rainfall so great and long continued as to affect injuriously the plant and animal kingdoms and to deplete water supplies, both for domestic purposes and for the operation of power plants, especially in those regions where the rainfall is normally sufficient for such purposes."

Strangely enough the Weather Bureau spelled it "drought" but the Department of Agriculture, of which the bureau is but a part, spells it "drouth."

No less an authority than the Managing Editor of Funk and Wagnall's Standard Dictionary, Dr. F. H. Vizetelly, casts his vote in favor of spelling it "drought." Says Mr. Vizetelly, "drouthe" was the early form used in the literature of 1393 and later was changed to "droughte" and first appeared as "drought" in Coverdale's translation of the Bible in 1535.

Tennyson, Sir Walter Scott, Browning and Swinburne—the latter as late as 1865—spelled it "drouth" as does the Department of Agriculture, but, says Mr. Vizetelly, these were all literary fellows who played around with words to suit their purposes. For ordinary use in compiling reports and the like he believes the good, sound, standardized form of "drought" should be preferred. After all there is nothing very poetic in the charts and tabulation of the Department of Agriculture.

Strangely enough the dictionary carries the word "drouk" right next to "drought" and that word is defined as follows:

Drouk:—to "drouk" is to wet through and through; to saturate.

▼

The Press and the City's Business

EVERY year the Census Bureau issues a report on the financial statistics of cities,—"with the hope that it may be of assistance to the officials who are charged with responsibilities incident to the administration of local government and the betterment of local communiies,"

The latest report gives added evidence of the important part that cities of 30,000 and over are playing in national expenditures. They pay $50 per capita in taxes on about $80,000,000,000 property value. These 250 cities of more than 30,000 population "spend more every year than half as much again as do all of the states put together and nearly as much as the Federal Government"—so says the "New York Times." The per capita cost of the business of a city has risen from an average figure of $16 in 1903 to $56 in 1929.

It is of interest to note the distribution of expenditures made by this group of cities. Education stands at the top with 38 per cent, conservation of health at the bottom with less than 3 per cent. "Protecion to person and property" requires about 20 per cent, hospitals and prisons 6 per cent, and recreation 4 per cent.

The "New York Times," commenting editorially on the exceedingly low expenditure for conservation of health, says that "the attotment for health protection and sanitation should increase as the years go by and the laggard cities catch up with the procession of cities, here and abroad, that have adopted modern methods of sewage and garbage disposal."

In commenting on a paragraph taken from "Health News," the official organ of the New York State Department of Health, the "New York Sun" in its editorial columns remarks—"that knowledge of reasonable precaution to safeguard the health is so widespread that it is only a question of time when there will be a general recognition of the fact that the mere existence of a case of typhoid fever is prima-facie evidence of culpable negligence somewhere, . . . but this is not the whole story;" and then quooting from "Health News" adds:

> "There are undoubtedly . . . cities which have been hesitating over the construction of a sewage treatment plant. . . . The filtration plant or the waterworks system may be in need of repairs, or additional waterworks may be necessary to avoid a water shortage. . . . The expenditure of funds at the present time for such purposes will not only improve health and sanitary conditions but will help restore economic stability."

It is invigorating to see the increasing interest that the leading newspapers of America are taking in the matter of securing improved water supply and sewage disposal, and better health and sanitary conditions in our cities. There can be no more effective means of encouraging municipal authorities and tax payers to devote adequate funds to improve the general sanitary conditions of the community than that of securing strong support by the press.

▼

Ambitendent Scientists

THE personality of scientists in general is reflected in AMBITENDENCE, PARANOIA and ANANCASM.

Dr. Eugene Kahn of the Institute of Human Relations at Yale University has applied these formidable-sounding terms in expressing his opinion of the scientist. The members of the National Academy of Scientists whom Dr. Kuhn was addressing were not angered however, or at least they were not provided they knew how the words were spelled and then looked up their meaning in some enclycopedia after the meeting.

The terms are not as uncomplimentary as they sound,—quite the contrary. They mean that the scientist is able to see fairly both sides of a question; that he is skeptical or suspicious or circumstances that may go unquestioned by his less thoughtful neighbors; and he has a forceful personality.

Regardless of the complimentary remarks of Dr. Kahn, we believe that a good fight might result if some day the chief engineer or the superintendent went into the laboratory and with criminal intent told the bacterioologist or chemist that he was *"ambitendent,"* had an *"anancastic"* personality and a *"paranoidal"* disposition.

L. H. Enslow

YE PILGRIMS PROGRESS OR—

How the Divine Mysteries of Activated Carbon Were Revealed to Mortal Sight

By THOMAS H. FERRIL
Denver, Colo.

Sweet Muse, may I adsorb thy lyre,
That I may sing a blurb on
The mysteries revealed to me
By activated carbon.

Like Joan of Arc my vision came
One day when fish refused to bite,
Although I'd used approved technic
With fly and helgramite.

Afar I heard an angel choir
That seemed to whisped through the mist:
"Why don't you bait your hook with something
Fish cannot resist?"

With that I cast away the worm
I couldn't catch a carp on,
Then using cinders for my bait,
By grab, I caught a tarpon.

"What strange magnetic thing is this?"
I cried in holy rapture,
Then I set forth in knightly quest
For other worlds to capture.

"You ain't seen nothin' yet," I heard,
Then this angelic query:
"Why not change something from black to white
With your swell carbon, dearie?"

Then I saw where a melon patch
Held pickaninnies legion;
I fed them carbon—each became
As blond as a Norwegian.

Again the angel voices said:
"If you'll just keep on trying,
You'll find this magic carbon is
A bear at purifying."

Just then I met a traveling man,
And gave him food and water;
His mind was evil, for he told
About the farmer's daughter.

Alas, he was a lustful man,
Sin lurked his every feature,
I fed him carbon and he's now
A noted Baptist preacher.

I ran across a naughty book
Called "Lady Chatterly's Lover."
I sprinkled carbon on each page
And purified each cover.

I shut my eyes and counted ten
And chanted an Hosanna,
And thereupon the naughty book
Turned into "Pollyanna."

With activated carbon I
Have captured colloid gums,
From radios I've filtered out
The alternating hums.

The fusel oil in local moon,
The amines in the brew,
Fermented dandelion sludge
I've also captured, too.

Old vegetables and bones I burn
And pulverize and bust
For activating carbon when
I can't get diamond dust.

An Efficient Type of Aerator for Tropical Waters. Capacity, 8,000,000 Gals. per Day. Aerator Covered with ⅛-In. Screen Cloth

WATER PURIFICATION AT CALI, IN THE TROPICS

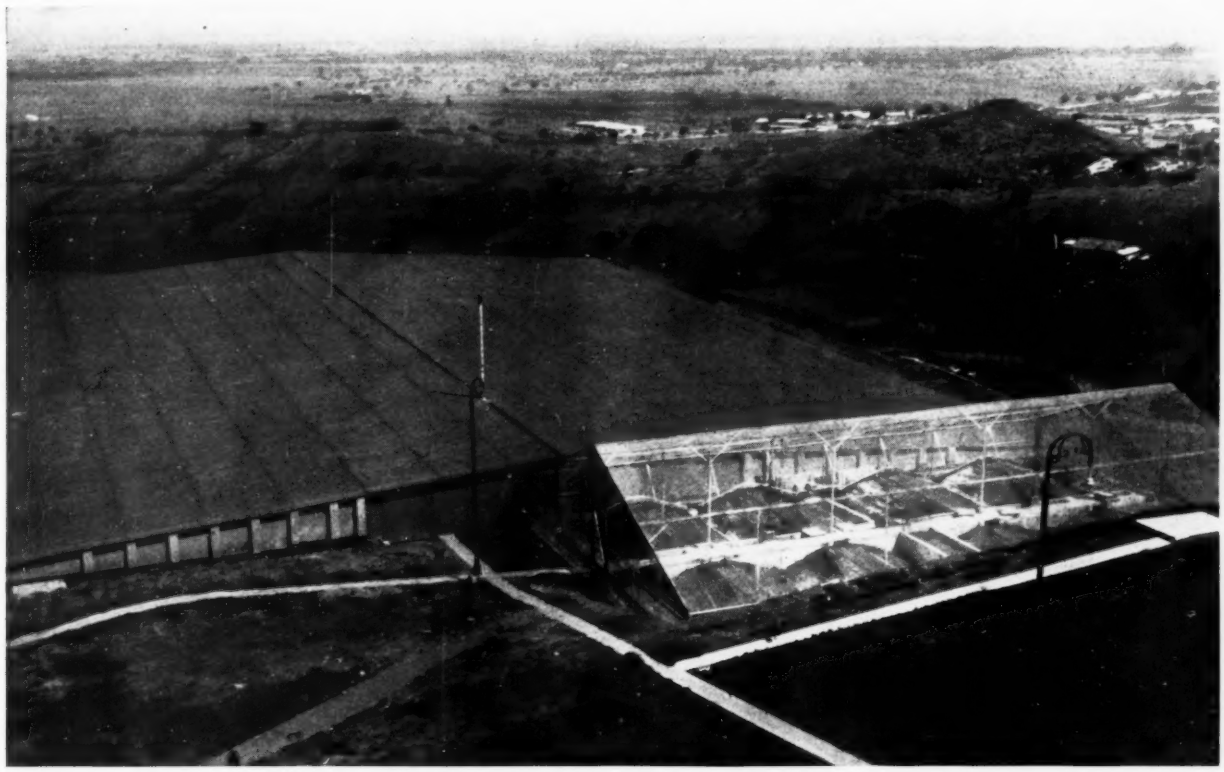
THE great number of crawling animals and flying insects in tropical countries create continuous problems in water treatment and storage which are considerably more pronounced than those met with in the Temperate Zones.

Filtered water reservoirs must be tightly covered, if algae growths are to be controlled and animals and insects kept out. The intensity and continuity of ultra violet light in the sunshine of the tropics makes it necessary to cope with profuse algae growths in clear water reservoirs. Likewise residual chlorine, because of light intensity, is rapidly dissipated when chlorinated water is exposed to tropical or semi-tropical sunshine.

In a recent communication from George C. Bunker*, consulting engineer and chemist of Ancon, Canal Zone, who designed and supervised construction of the filtration plant at Cali, Columbia, S. A., the following paragraph has been taken.

"I wonder if you have ever seen an aerator for filtered water enclosed in wire mesh screening to prevent birds and bugs from entering the water. The mesh of the screening is a little larger than ⅛ in. At various times during the year there are swarms of large bugs, similar to the June bug in the States, which fall into the water. Before the plant was built they would fall into the open storage tanks and some of them would sink and be carried into the service pipes. I am enclosing two views to show the aerator. The chlorine is added to the filtered water before it enters the aerator and there is very little loss of chlorine during the passage through it. I get wonderful results at this plant with the application of from .13 to .19 parts per million of cholrine in conjunction with the aeration and storage in the reservoir shown below the aerator."

**Editor's Note:* Mr. Bunker was presented with a gold medal by the city council of Cali upon the occasion of the formal opening and acceptance of the new filtration plant.



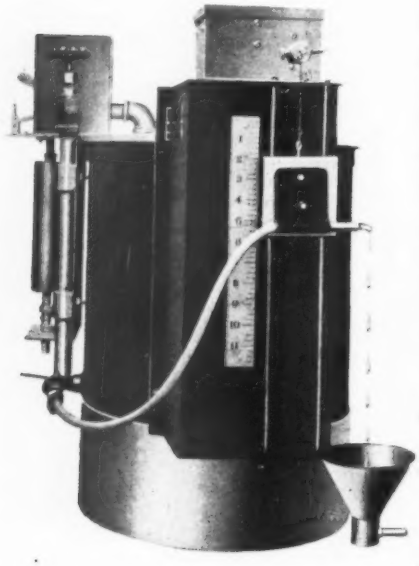
Aerator for Filtered Water Enclosed by Wire Netting to Keep Out Bugs. Covered Reservoir, 2 M.G. Capacity, Shown Below Aerator

NEW EQUIPMENT AND MATERIALS

New Precision Feeder and Laboratory Stirrer

A new feeding and measuring device of the solution type which will handle an extremely wide variety of materials has been brought out by the Omega Machine Co., 4010 Penn Ave., Kansas City, Mo.

The feeder was developed primarily for feeding relatively small quantities from a few grains to 100 lbs. or more per day, and for handling solutions of materials such as chlorinated lime "H T H," caustic soda, ammonium sulphate, "Perchloron," etc.



Omega Precision Feeder

The feeder is designed on the principle of filling a tank with liquid or solution of known strength. To an outlet near the bottom of the tank a flexible hose, or pipe, is connected, located either inside or outside the tank, with the movable end of the hose level with the liquid in the tank. The movable end of the outlet hose is then lowered by suitable mechanical means at such a rate that a known amount of solution will be delivered from the tank in a given time interval.

By the use of suitable control mechanism the solution from the tank may be delivered at a uniform rate or at a rate proportional to some other function, such as the flow of water through a meter or over a weir. If an intermittent feed is desired the device can also be arranged to measure and deliver fixed quantities of solution at predetermined intervals.

The control mechanism is, in most cases, electrically operated by a synchronous motor, but clock mechanisms or other forms of control are available. The solution tanks may be of any required size, from 1 gal. upwards. Tanks and fittings are constructed of glass, earthenware, rubber, steel, acid-resistant metals, or other materials suitable for the particular service required.

The tank is generally designed to hold enough material for a 24 hour run. The maximum capacity is limited only by the capacity of the solution tank, which may be of any desired size.

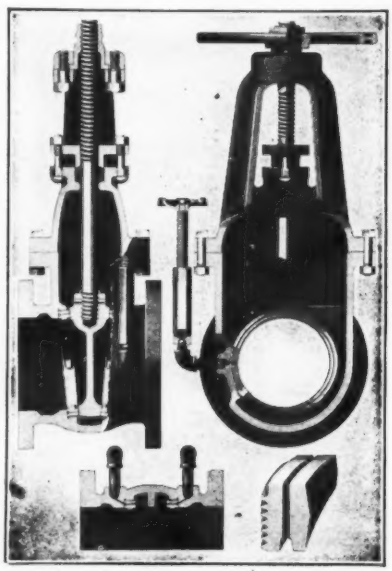
The Omega Machine Co. also has brought out a new laboratory stirrer. This device is primarily for use in water purification and softening plants for stirring samples of water, treated with various amounts of coagulants or softening chemicals, to determine the dosage, degree of agitation and the mixing and settling periods required for the best results.

The device has a heavy steel frame, supporting the motor, which is directly connected by a drive shaft to each of the stirring units which are driven by individual worm gears running in oil. The vertical agitator shafts revolve at a speed of 60 r. p. m. It is not necessary to stop the machine in order to put in or remove a sample being tested.

The stirrer is made in four sizes, with three, four, five or six units as may be required. The three-unit size is 7 in. wide, 21 in. high and 27 in. long and will accommodate three jars of any size up to 1 gal., and any height up to 12 in. Each additional unit increases the length 7 in.

The Lubrotite Gate Valve

A gate valve having a unique duct system for introducing a lubricant-seal between the seating surfaces has been brought out by the Reading-Pratt & Cady Co., Inc., Bridgeport, Conn. It is stated that the valve is sealed tight even though the seating surfaces have become damaged by scratches, deposits, or corrosion in the line. Among other advantages claimed for the valve are:



Lubrotite Valve

Seating surfaces protected by film of lubricant. They will not become corroded, scratched, or injured easily. Frees set wedge—lubricant-seal separates wedge from seats slightly freeing wedge that has become set from a long period of service.

The Lubrotite valves are made in both Pratt & Cady standard and extra heavy iron body patterns, and in Reading electric cast steel. The general dimensions are the same as the non-lubricated valves, so Lubrotite valves can be used for replacement service without changing the piping system in any way.

All valves seat absolutely tight without the use of the lubricant-seal and can be used, if desired, as regular non-lubricated valves.

Lubricant-seals are supplied for various services—air, gas, water, chemical, petroleum products, etc. The Lubricant-seals are packed in convenient pocket sized boxes—24 cartridges to a box. Only a small amount of lubricant is needed for an application.

Ditcher Mounted on Pneumatic Tires Travels Under Own Power

A new development in small ditchers has been announced by the National Equipment Corporation, Milwaukee, Wis.

The new ditcher, which will be known as the Parsons Model 14, was designed to meet the needs of contractors and public utilities interested in laying small pipe lines, gas and water mains, house connections and conduits. Easy portability was desired to reduce the costs for short extensions, service connections and simliar trench work over a widespread area.

New Parsons Ditcher, Model 14

Mounted on pneumatic tires, the Parsons 14 is instantly available to travel to the job under its own power while observing only the regulations applying to the operation of motor trucks over the streets and highways.

WATER WORKS & SEWERAGE

L. H. ENSLOW, Editor

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THIS MONTH »»

An important article in this issue describes the use of the lime-chlorine method of treatment at the Dayton, O., sewage treatment plant. Two conventions in the South of water works and sewerage associations are covered in this issue. John R. Baylis concludes his article on the characteristics of activated carbon. Another interesting article deals with the development of a water supply for Santiago de Cuba.

AND NEXT »»

The articles of primary interest that will appear in the January issue include the following: "Development in Water Supply During 1931—a review of progress by Norman J. Howard, Toronto; "Zeolite Process of Water Softening," by Chas. P. Hoover; "Sludge Disposal at the Baltimore Sewage Works," by C. E. Keefer; "Comparison of Sewage Treatment in the U. S. with That of Los Angeles Experimental Station," by B. F. Goudey.

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For trouble-free operation *put down* CAST IRON SEWER MAINS

THERE are three important reasons why many engineers today are specifying cast iron pipe for important sewer lines. In the first place, cast iron mains effectively resist free acids. Secondly, cast iron sewer mains are unharmed by friction from heavy grit or gravel. Thirdly, tree roots cannot work into and clog a properly constructed cast iron sewer line.

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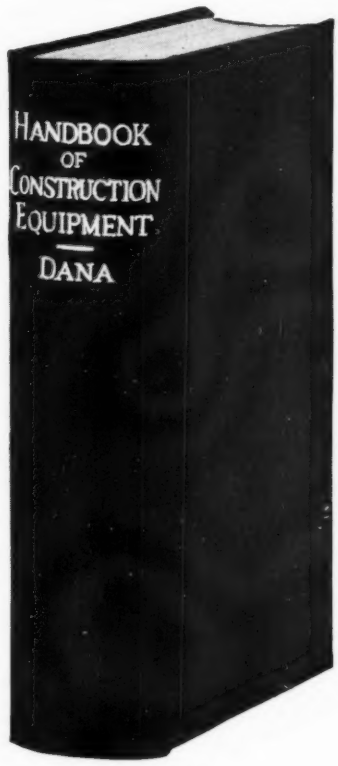
Engineers and contractors seeking further information regarding the advantages of specifying cast iron pipe for sewer mains are invited to write to The Cast Iron Pipe Research Association, Thomas F. Wolfe, Research Engineer, 309 Peoples Gas Building, Chicago, Illinois.

Cast iron pipe bearing the "Q-check" trademark is obtainable from the following leading pipe founders: Alabama Pipe Company, Anniston, Ala.; American Cast Iron Pipe Company, Birmingham, Ala.; James B. Clow & Sons, 219 N. Talman Avenue, Chicago, Ill.; Donaldson Iron Company, Emaus, Pa.; Glamorgan Pipe and Foundry Company, Lynchburg, Va.; Lynchburg Foundry Company, Lynchburg, Va.; National Cast Iron Pipe Company, Birmingham, Ala.; United States Pipe and Foundry Company, Burlington, N. J.; Warren Foundry and Pipe Corp., 11 Broadway, New York.

Look for the "Q-check" symbol as shown above. It is the registered trademark of the Cast Iron Pipe Research Association.

CAST IRON PIPE

Familiar Methods
vs.
BEST METHODS



What is the biggest factor in successful construction work—Habit, or Knowledge? This question suggests a warning to the contractor against getting set in his ways, while business conditions, methods, and types of work are changing all around him. Most of all, equipment and its uses are showing new developments. Richard T. Dana bridges the gap from the familiar way of doing things to the *one best way among many*,—in his "Handbook of Construction Equipment." For, after all, methods are tied up closely to equipment, and vary with improvements in tools and machinery.

Therefore this complete survey of available equipment for every type of work is a thorough survey of available methods. Knowledge at your finger tips! That's what this "Handbook" offers,—and you gain the benefit of that Knowledge superimposed on your own experience.

We'd like you to be the ultimate judge of the value in your work of the "Handbook of Construction Equipment." This is how we enable you to judge cost-free: Send the coupon, receive the book, examine it, then within ten days return it or remit in accordance with the offer detailed in the coupon. Clip and mail it today.

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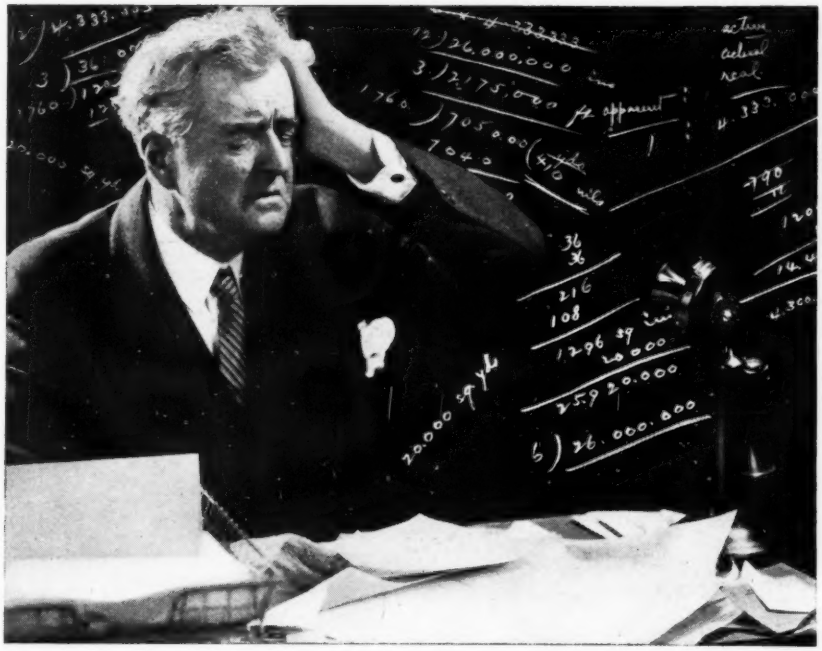
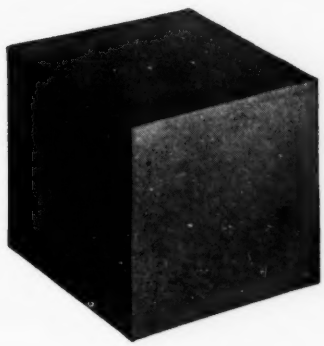
BOY! *Page* Mr. E*instein!*





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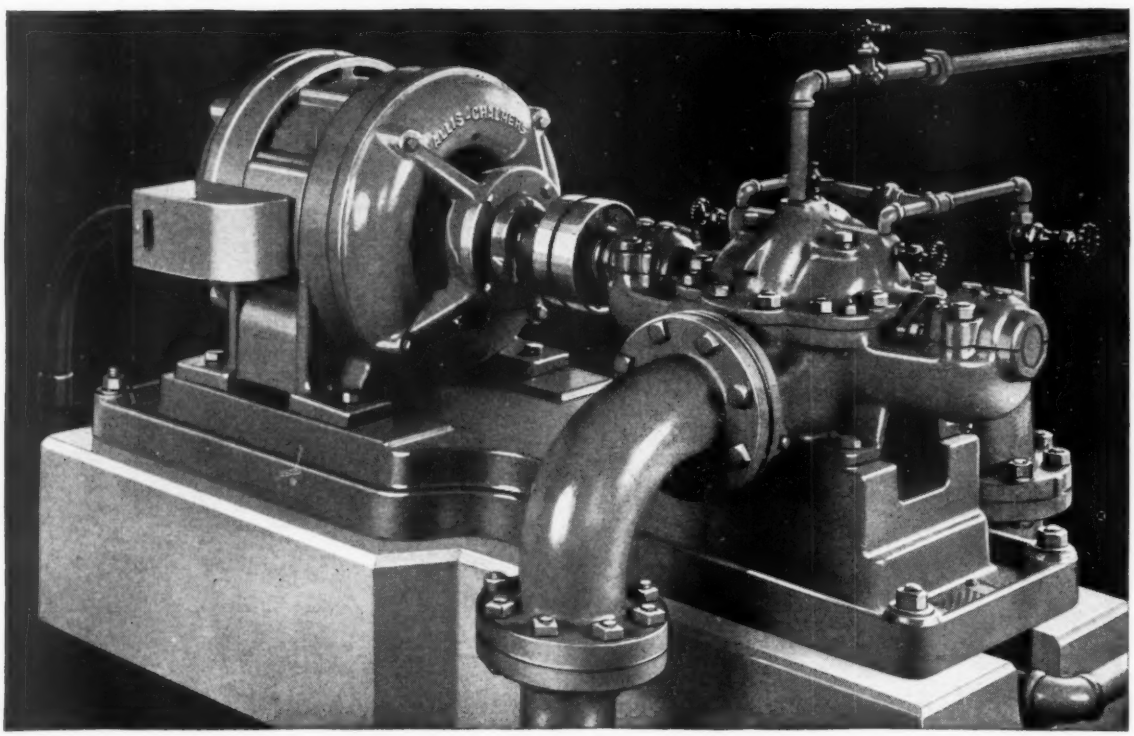

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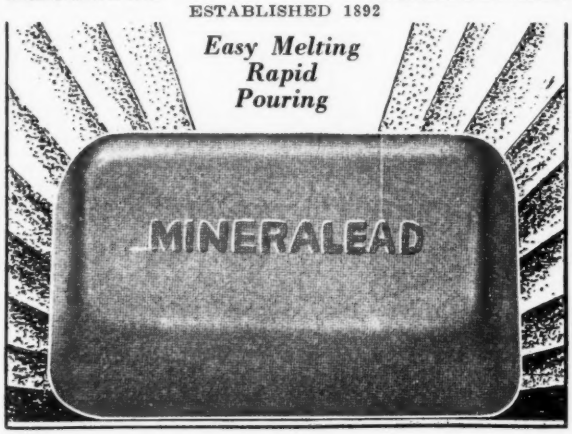
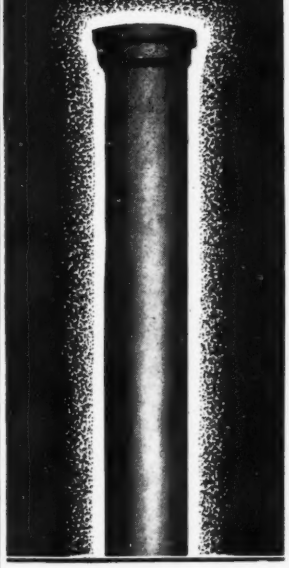


IT'S IN THE PIPE



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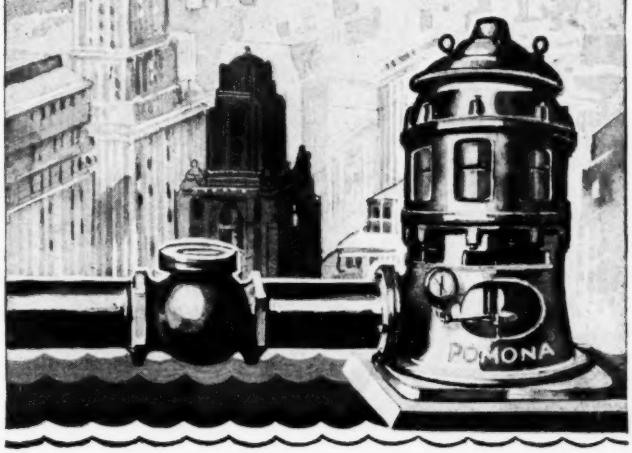
The Trend is toward Water Lubricated PUMPS



A study of various types of deep well pumps, on the part of waterworks engineers, leads to one logical conclusion—WATER LUBRICATION is the essential factor. So pronounced is the trend toward water lubrication that many health commissioners are insistent upon the selection of pumping equipment that does not require oil below the surface. Pomona Turbine Pumps built their reputation principally upon the elimination of oil lubrication. Years ago water lubrication was a revolutionary idea. Many engineers were skeptical. But today thousands of Pomona Pumps testify to the merit of such a principle and the same engineers are fully in accord with the idea.

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POMONA

WATER LUBRICATED TURBINE PUMPS

CALLS FOR BIDS

PRELIMINARY NOTICE TO CONTRACTORS

It is expected that bids will be called for December 7, 1931, by the Board of Contract and Supply of The Metropolitan District, Hartford County, for clearing the south end of the Barkhamsted Reservoir site.

The work to be done under this contract will consist of clearing about 250 acres of land located in the East Branch Valley of the Farmington River, just above the northerly end of the present Compensating Reservoir in the town of Barkhamsted, Connecticut, and the removal and disposal of all timber and brush from this area.

If this work is authorized, plans and specifications may be obtained on and after November 25, 1931, at the office of the Manager and Chief Engineer of the Water Bureau of The Metropolitan District, 1026 Main Street, Hartford, Connecticut.

BOARD OF CONTRACT AND SUPPLY,
By Richard Dillon, Clerk.

Hartford, Connecticut,
November 18, 1931.

PRELIMINARY NOTICE TO CONTRACTORS

It is expected that bids will be called for December 7, 1931, by the Board of Contract and Supply of the Metropolitan District, Hartford County, for making borings at the Bills Brook Dam Site in Barkhamsted, Connecticut.

The work to be done under this contract will consist of making about 1700 feet of borings, including the core drillings.

If this work is authorized, specifications can be obtained on and after November 25, 1931, at the office of the Manager and Chief Engineer of the Water Bureau of the Metropolitan District, 1026 Main Street, Hartford Connecticut.

BOARD OF CONTRACT AND SUPPLY,
By Richard Dillon, Clerk.

Hartford, Connecticut,
November 18, 1931.

CONTRACT 7—SAND WASHING MACHINE

Sealed proposals addressed to the Board of Contract and Supply of the Metropolitan District, and endorsed "PROPOSAL FOR FURNISHING AND ASSEMBLING SAND WASHING MACHINE" will be received at the Executive Office of the Metropolitan District of Hartford County, at the Municipal Building, 550 Main Street., Hartford, Connecticut, until 12 o'clock noon, Eastern Standard time, Monday, December 7, 1931, for furnishing, delivering and assembling one sand washing machine at the Water Bureau Filter Plant, West Hartford, Connecticut.

After the bids are opened and read, they will be taken under advisement by the District, and the award of the contract, if awarded, will be made as soon thereafter as practicable.

Specifications may be obtained on and after November 20, 1931, at the office of the Manager and Chief Engineer of the Water Bureau of the Metropolitan District, 1026 Main Street.

A bidding check of $1200 must be delivered to the Executive Secretary of the District when submitting the bid, and the successful bidder will be required to furnish a bond equal to the total sum bid for the faithful performance of the work.

The right is reserved to accept any bid, whether or not the lowest, or to reject any or all bids, as the interest of the District may appear to require.

BOARD OF CONTRACT AND SUPPLY,
By Richard Dillon, Clerk.

Hartford, Connecticut,
November 17, 1931.

CONTRACT 8—PORTABLE AIR COMPRESSOR

Sealed proposals addressed to the Board of Contract and Supply of the Metropolitan District, and endorsed "PROPOSAL FOR FURNISHING AND DELIVERING ONE PORTABLE AIR COMPRESSOR" will be received at the Executive Office of the Metropolitan District of Hartford County, at the Municipal Building, 550 Main Street, Hartford, Connecticut, until 12 o'clock noon, Eastern Standard time, Monday, December 7, 1931, for furnishing and delivering one portable air compressor to the Water Bureau at Union Street Yard, Hartford, Connecticut.

After the bids are opened and read, they will be taken under advisement by the District, and the award of the contract, if awarded, will be made as soon thereafter as practicable.

Specifications may be obtained on and after November 20, 1931, at the office of the Manager and Chief Engineer of the Water Bureau of the Metropolitan District, 1026 Main Street.

A bidding check of $300 must be delivered to the Executive Secretary of the District when submitting the bid, and the successful bidder will be required to furnish a bond equal to the total sum bid for the faithful performance of the work.

The right is reserved to accept any bid, whether or not the lowest, or to reject any or all bids, as the interest of the District may appear to require.

BOARD OF CONTRACT AND SUPPLY,
By Richard Dillon Clerk.

Hartford, Connecticut,
November 17, 1931.

CONTRACT 9—BORING

Sealed proposals addressed to the Board of Contract and Supply of the Metropolitan District, and endorsed "PROPOSAL FOR MAKING BORINGS AT THE BILLS BROOK DAM SITE IN BARKHAMSTED, CONNECTICUT" will be received at the Executive Office of the Metropolitan District of Hartford County, at the Municipal Building, 550 Main Street, Hartford, Connecticut, until 12 o'clock noon, Eastern Standard time, Monday, December 7, 1931, for making borings at the Bills Brook Dam Site, Barkhamsted, Connecticut.

The work to be done under this contract will consist of making about 1700 feet of borings, including the core drillings.

After the bids are opened and read, they will be taken under advisement by the District, and the award of the contract, if awarded, will be made as soon thereafter as practicable.

Specifications may now be obtained at the office of the Manager and Chief Engineer of the Water Bureau of the Metropolitan District, 1026 Main Street.

A bidding check of $1000 must be delivered to the Executive Secretary of the District when submitting the bid, and the successful bidder will be required to furnish a bond equal in amount to the total sum bid to the nearest hundred dollars for the faithful performance of the work.

The right is reserved to accept any bid, whether or not the lowest, or to reject any or all bids, as the interest of the District may appear to require.

BOARD OF CONTRACT AND SUPPLY
by Richard Dillon, Clerk.

Hartford, Connecticut
November 25, 1931

CONTRACT 10—CLEARING

Sealed proposals addressed to the Board of Contract and Supply of the Metropolitan District, and endorsed "PROPOSAL FOR CLEARING SOUTH END OF BARKHAMSTED RESERVOIR IN BARKHAMSTED, CONNECTICUT" will be received at the Executive Office of the Metropolitan District of Hartford County, at the Municipal Building, 550 Main Street, Hartford, Connecticut, until 12 o'clock noon, Eastern Standard time, Monday, December 7, 1931, for clearing the south end of the Barkhamsted Reservoir site, Barkhamsted, Connecticut.

The work to be done under this contract will consist of clearing about 250 acres of land located in the East Branch Valley of the Farmington River, just above the northerly end of the present Compensating Reservoir in the Town of Barkhamsted, Connecticut, and the removal and disposal of all timber and brush from this area.

After the bids are opened and read, they will be taken under advisement by the District, and the award of the contract, if awarded, will be made as soon thereafter as practicable.

Specifications may now be obtained at the office of the Manager and Chief Engineer of the Water Bureau of the Metropolitan District, 1026 Main Street.

A bidding check of $1000 must be delivered to the Executive Secretary of the District when submitting the bid, and the successful bidder will be required to furnish a bond equal in amount to the total sum bid under Item 1, to the nearest hundred dollars for the faithful performance of the work.

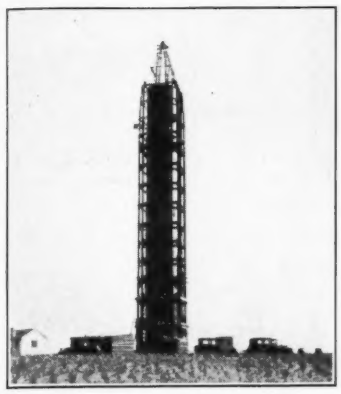
The right is reserved to accept any bid, whether or not the lowest, or to reject any or all bids, as the interest of the District may appear to require.

BOARD OF CONTRACT AND SUPPLY
by Richard Dillon, Clerk.

Hartford, Connecticut
November 25, 1931

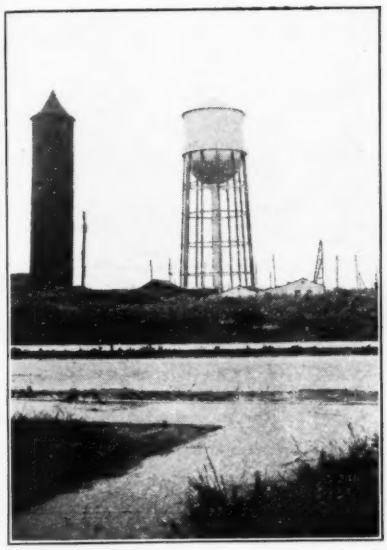
Sell Your Used Equipment before storage and depreciation on it eat up the profits on that last job.

Use Our Clearing House Section.



Long Island's State Park Stores Water at Jones Beach in a "Pittsburgh-Des Moines" Tower

The Long Island State Park Commission is conducting an experiment in civic beauty and cleanliness at Jones Beach — an interesting resort near Long Beach on the south shore. Park grounds, walks, beaches, and even the highways are maintained free from the usual litter, trash and picnic refuse of a metropolitan beach resort by vigilant policing—and the public's willing cooperation.



ONE of the primary essentials was plenty of good, clean water in a quality holder. "Pittsburgh-Des Moines" was called upon for the erection of a 300,000 gallon steel standpipe, shown under construction at the left above, and shown completed (with its ornamental masonry) at the right. This architecturally pleasing tower has a diameter of 19 feet; a height of 150 feet.

At the left is shown a 750,000 gallon elevated tank, 100 feet high to capacity, also erected the past summer by "Pittsburgh-Des Moines" to supply water at adequate pressures to the neighboring city of Long Beach.

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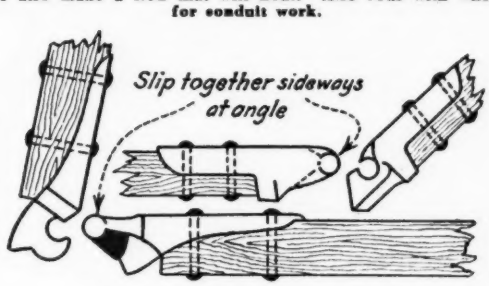

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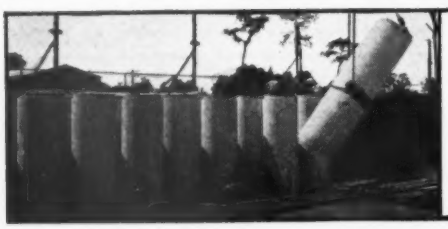

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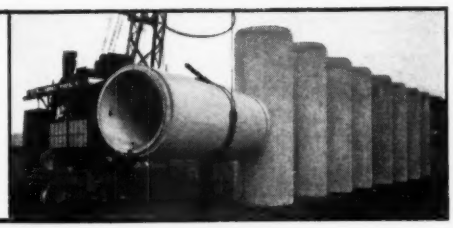

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